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within: **Gr.7, Gr.8, Gr.9, Gr.10, Gr.11, Gr.12**
within: **Mathematics**

Gr.7 Mathematics---Number Sense and Numeration

Quantity Relationships

- ☐ **7m12** **SQC2005** – generate multiples and factors, using a variety of tools and strategies (e.g., identify multiples on a hundreds chart; create rectangles on a geoboard) (Sample problem: List all the rectangles that have an area of 36 cm2 and have whole-number dimensions.);
- ☐ **7m17** **SQC2005** – explain the relationship between exponential notation and the measurement of area and volume (Sample problem: Explain why area is expressed in square units [units^2] and volume is expressed in cubic units [units^3].).

Operational Sense

- ☐ **7m22** **SQC2005** – use estimation when solving problems involving operations with whole numbers, decimals, and percents, to help judge the reasonableness of a solution (Sample problem: A book costs $18.49. The salesperson tells you that the total price, including taxes, is $22.37. How can you tell if the total price is reasonable without using a calculator?);

Proportional Relationships

- ☐ **7m28** **SQC2005** – solve problems that involve determining whole number percents, using a variety of tools (e.g., base ten materials, paper and pencil, calculators) (Sample problem: If there are 5 blue marbles in a bag of 20 marbles, what percent of the marbles are not blue?);
- ☐ **7m30** **SQC2005** – solve problems involving the calculation of unit rates (Sample problem:You go shopping and notice that 25 kg of Ryan's Famous Potatoes cost $12.95, and 10 kg of Gillian's Potatoes cost $5.78. Which is the better deal? Justify your answer.).

Gr.7 Mathematics---Measurement

Measurement Relationships

- ☐ **7m34** **SQC2005** – sketch different polygonal prisms that share the same volume (Sample problem: The Neuman Company is designing a new container for its marbles. The container must have a volume of 200 cm^3. Sketch three possible containers, and explain which one you would recommend.);
- ☐ **7m35** **SQC2005** – solve problems that require conversion between metric units of measure (e.g., millimetres and centimetres, grams and kilograms, millilitres and litres) (Sample problem: At Andrew's Deli, cheese is on sale for $11.50 for one kilogram. How much would it cost to purchase 150 g of cheese?);
- ☐ **7m36** **SQC2005** – solve problems that require conversion between metric units of area (i.e., square centimetres, square metres) (Sample problem: What is the ratio of the number of square metres to the number of square centimetres for a given area? Use this ratio to convert 6.25 m^2 to square centimetres.);
- ☐ **7m37** **SQC2005** – determine, through investigation using a variety of tools (e.g., concrete materials, dynamic geometry software) and strategies, the relationship for calculating the area of a trapezoid, and generalize to develop the formula [i.e., Area = (sum of lengths of parallel sides x height) ÷ 2] (Sample problem: Determine the relationship between the area of a parallelogram and the area of a trapezoid by composing a parallelogram from congruent trapezoids.);
- ☐ **7m39** **SQC2005** – estimate and calculate the area of composite two-dimensional shapes by decomposing into shapes with known area relationships (e.g., rectangle, parallelogram, triangle) (Sample problem: Decompose a pentagon into shapes with known area relationships to find the area of the pentagon.);
- ☐ **7m40** **SQC2005** – determine, through investigation using a variety of tools and strategies (e.g., decomposing right prisms; stacking congruent layers of concrete materials to form a right prism), the relationship between the height, the area of the base, and the volume of right prisms with simple polygonal bases (e.g., parallelograms, trapezoids), and generalize to develop the formula (i.e., Volume = area of base x height) (Sample problem: Decompose right prisms with simple polygonal bases into triangular prisms and rectangular prisms. For each prism, record the area of the base, the height, and the volume on a chart. Identify relationships.);

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- ☐ **7m42** **SQC2005** – solve problems that involve the surface area and volume of right prisms and that require conversion between metric measures of capacity and volume (i.e., millilitres and cubic centimetres) (Sample problem: An aquarium has a base in the shape of a trapezoid. The aquarium is 75 cm high. The base is 50 cm long at the front, 75 cm long at the back, and 25 cm wide. Find the capacity of the aquarium.).

Gr.7 Mathematics---Geometry and Spatial Sense

Geometric Properties

- ☐ **7m47** **SQC2005** – sort and classify triangles and quadrilaterals by geometric properties related to symmetry, angles, and sides, through investigation using a variety of tools (e.g., geoboard, dynamic geometry software) and strategies (e.g., using charts, using Venn diagrams) (Sample problem: Investigate whether dilatations change the geometric properties of triangles and quadrilaterals.);
- ☐ **7m49** **SQC2005** – investigate, using concrete materials, the angles between the faces of a prism, and identify right prisms (Sample problem: Identify the perpendicular faces in a set of right prisms.).

Geometric Relationships

- ☐ **7m51** **SQC2005** – determine, through investigation using a variety of tools (e.g., dynamic geometry software, concrete materials, geoboard), relationships among area, perimeter, corresponding side lengths, and corresponding angles of congruent shapes (Sample problem: Do you agree with the conjecture that triangles with the same area must be congruent? Justify your reasoning.);
- ☐ **7m53** **SQC2005** – distinguish between and compare similar shapes and congruent shapes, using a variety of tools (e.g., pattern blocks, grid paper, dynamic geometry software) and strategies (e.g., by showing that dilatations create similar shapes and that translations, rotations, and reflections generate congruent shapes) (Sample problem: A larger square can be composed from four congruent square pattern blocks. Identify another pattern block you can use to compose a larger shape that is similar to the shape of the block.).

Location and Movement

- ☐ **7m56** **SQC2005** – create and analyse designs involving translations, reflections, dilatations, and/or simple rotations of two-dimensional shapes, using a variety of tools (e.g., concrete materials, Mira, drawings, dynamic geometry software) and strategies (e.g., paper folding) (Sample problem: Identify transformations that may be observed in architecture or in artwork [e.g., in the art of M.C. Escher].);

Gr.7 Mathematics---Patterning and Algebra

Patterns and Relationships

- ☐ **7m61** **SQC2005** – make predictions about linear growing patterns, through investigation with concrete materials (Sample problem: Investigate the surface area of towers made from a single column of connecting cubes, and predict the surface area of a tower that is 50 cubes high. Explain your reasoning.);
- ☐ **7m63** **SQC2005** – compare pattern rules that generate a pattern by adding or subtracting a constant, or multiplying or dividing by a constant, to get the next term (e.g., for 1, 3, 5, 7, 9, …, the pattern rule is "start at 1 and add 2 to each term to get the next term") with pattern rules that use the term number to describe the general term (e.g., for 1, 3, 5, 7, 9, …, the pattern rule is "double the term number and subtract 1", which can be written algebraically as 2 x n – 1) (Sample problem: For the pattern 1, 3, 5, 7, 9, …, investigate and compare different ways of finding the 50th term.).

Variables, Expressions, and Equations

- ☐ **7m64** **SQC2005** – model real-life relationships involving constant rates where the initial condition starts at 0 (e.g., speed, heart rate, billing rate), through investigation using tables of values and graphs (Sample problem: Create a table of values and graph the relationship between distance and time for a car travelling at a constant speed of 40 km/h. At that speed, how far would the car travel in 3.5 h? How many hours would it take to travel 220 km?);

Gr.7 Mathematics---Data Management and Probability

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Collection and Organization of Data

- ☐ **7m77** **SQC2005** – identify bias in data collection methods (Sample problem: How reliable are your results if you only sample girls to determine the favourite type of book read by students in your grade?).

Data Relationships

- ☐ **7m80** **SQC2005** – determine, through investigation, the effect on a measure of central tendency (i.e., mean, median, and mode) of adding or removing a value or values (e.g., changing the value of an outlier may have a significant effect on the mean but no effect on the median) (Sample problem: Use a set of data whose distribution across its range looks symmetrical, and change some of the values so that the distribution no longer looks symmetrical. Does the change affect the median more than the mean? Explain your thinking.);
- ☐ **7m82** **SQC2005** – make inferences and convincing arguments that are based on the analysis of charts, tables, and graphs (Sample problem: Use census information to predict whether Canada's population is likely to increase.).

Probability

- ☐ **7m84** **SQC2005** – make predictions about a population when given a probability (Sample problem: The probability that a fish caught in Lake Goodfish is a bass is 29%. Predict how many bass will be caught in a fishing derby there, if 500 fish are caught.);
- ☐ **7m85** **SQC2005** – represent in a variety of ways (e.g., tree diagrams, tables, models, systematic lists) all the possible outcomes of a probability experiment involving two independent events (i.e., one event does not affect the other event), and determine the theoretical probability of a specific outcome involving two independent events (Sample problem: What is the probability of rolling a 4 and spinning red, when you roll a number cube and spin a spinner that is equally divided into four different colours?);
- ☐ **7m86** **SQC2005** – perform a simple probability experiment involving two independent events, and compare the experimental probability with the theoretical probability of a specific outcome (Sample problem: Place 1 red counter and 1 blue counter in an opaque bag. Draw a counter, replace it, shake the bag, and draw again. Compare the theoretical and experimental probabilities of drawing a red counter 2 times in a row.).

Gr.8 Mathematics---Number Sense and Numeration

Operational Sense

- ☐ **8m17** **SQC2005** – solve problems involving percents expressed to one decimal place (e.g., 12.5%) and whole-number percents greater than 100 (e.g., 115%) (Sample problem: The total cost of an item with tax included [115%] is $23.00. Use base ten materials to determine the price before tax.);
- ☐ **8m24** **SQC2005** – multiply and divide decimal numbers by various powers of ten (e.g., "To convert 230 000 cm^3 to cubic metres, I calculated in my head 230000 ÷ 10^6 to get 0.23 m^3.") (Sample problem: Use a calculator to help you generalize a rule for dividing numbers by 1 000 000.);
- ☐ **8m25** **SQC2005** – estimate, and verify using a calculator, the positive square roots of whole numbers, and distinguish between whole numbers that have whole-number square roots (i.e., perfect square numbers) and those that do not (Sample problem: Explain why a square with an area of 20 cm^2 does not have a whole-number side length.).

Proportional Relationships

- ☐ **8m27** **SQC2005** – solve problems involving proportions, using concrete materials, drawings, and variables (Sample problem: The ratio of stone to sand in HardFast Concrete is 2 to 3. How much stone is needed if 15 bags of sand are used?);
- ☐ **8m28** **SQC2005** – solve problems involving percent that arise from real-life contexts (e.g., discount, sales tax, simple interest) (Sample problem: In Ontario, people often pay a provincial sales tax [PST] of 8% and a federal sales tax [GST] of 7% when they make a purchase. Does it matter which tax is calculated first? Explain your reasoning.);
- ☐ **8m29** **SQC2005** – solve problems involving rates (Sample problem: A pack of 24 CDs costs $7.99. A pack of 50 CDs costs $10.45. What is the most economical way to purchase 130 CDs?).

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Gr.8 Mathematics---Measurement

Attributes, Units, and Measurement Sense

- ☐ **8m32** **SQC2005** – research, describe, and report on applications of volume and capacity measurement (e.g., cooking, closet space, aquarium size) (Sample problem: Describe situations where volume and capacity are used in your home.).

Measurement Relationships

- ☐ **8m33** **SQC2005** – solve problems that require conversions involving metric units of area, volume, and capacity (i.e., square centimetres and square metres; cubic centimetres and cubic metres; millilitres and cubic centimetres) (Sample problem: What is the capacity of a cylindrical beaker with a radius of 5 cm and a height of 15 cm?);
- ☐ **8m34** **SQC2005** – measure the circumference, radius, and diameter of circular objects, using concrete materials (Sample Problem: Use string to measure the circumferences of different circular objects.);
- ☐ **8m35** **SQC2005** – determine, through investigation using a variety of tools (e.g., cans and string, dynamic geometry software) and strategies, the relationships for calculating the circumference and the area of a circle, and generalize to develop the formulas [i.e., Circumference of a circle = π x diameter; Area of a circle = π x $(\text{radius})^2$] (Sample problem: Use string to measure the circumferences and the diameters of a variety of cylindrical cans, and investigate the ratio of the circumference to the diameter.);
- ☐ **8m38** **SQC2005** – determine, through investigation using concrete materials, the surface area of a cylinder (Sample problem: Use the label and the plastic lid from a cylindrical container to help determine its surface area.);
- ☐ **8m39** **SQC2005** – solve problems involving the surface area and the volume of cylinders, using a variety of strategies (Sample problem: Compare the volumes of the two cylinders that can be created by taping the top and bottom, or the other two sides, of a standard sheet of paper.).

Gr.8 Mathematics---Geometry and Spatial Sense

Geometric Properties

- ☐ **8m43** **SQC2005** – sort and classify quadrilaterals by geometric properties, including those based on diagonals, through investigation using a variety of tools (e.g., concrete materials, dynamic geometry software) (Sample problem: Which quadrilaterals have diagonals that bisect each other perpendicularly?);

Geometric Relationships

- ☐ **8m46** **SQC2005** – determine, through investigation using a variety of tools (e.g., dynamic geometry software, concrete materials, geoboard), relationships among area, perimeter, corresponding side lengths, and corresponding angles of similar shapes (Sample problem: Construct three similar rectangles, using grid paper or a geoboard, and compare the perimeters and areas of the rectangles.);
- ☐ **8m51** **SQC2005** – determine, through investigation using concrete materials, the relationship between the numbers of faces, edges, and vertices of a polyhedron (i.e., number of faces + number of vertices = number of edges + 2) (Sample problem: Use Polydrons and/or paper nets to construct the five Platonic solids [i.e., tetrahedron, cube, octahedron, dodecahedron, icosahedron], and compare the sum of the numbers of faces and vertices to the number of edges for each solid.).

Gr.8 Mathematics---Patterning and Algebra

Patterns and Relationships

- ☐ **8m58** **SQC2005** – determine a term, given its term number, in a linear pattern that is represented by a graph or an algebraic equation (Sample problem: Given the graph that represents the pattern 1, 3, 5, 7, …, find the 10th term. Given the algebraic equation that represents the pattern, $t = 2n - 1$, find the 100th term.).

Variables, Expressions, and Equations

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- ☐ **8m60** **SQC2005** – model linear relationships using tables of values, graphs, and equations (e.g., the sequence 2, 3, 4, 5, 6, … can be represented by the equation t = n + 1, where n represents the term number and t represents the term), through investigation using a variety of tools (e.g., algebra tiles, pattern blocks, connecting cubes, base ten materials) (Sample problem: Leah put $350 in a bank certificate that pays 4% simple interest each year. Make a table of values to show how much the bank certificate is worth after five years, using base ten materials to help you. Represent the relationship using an equation.);
- ☐ **8m64** **SQC2005** – solve and verify linear equations involving a one-variable term and having solutions that are integers, by using inspection, guess and check, and a "balance" model (Sample problem: What is the value of the variable in the equation 30x – 5 = 10?).

Gr.8 Mathematics---Data Management and Probability

Data Relationships

- ☐ **8m75** **SQC2005** – demonstrate an understanding of the appropriate uses of bar graphs and histograms by comparing their characteristics (Sample problem: How is a histogram similar to and different from a bar graph? Use examples to support your answer.);
- ☐ **8m76** **SQC2005** – compare two attributes or characteristics (e.g., height versus arm span), using a scatter plot, and determine whether or not the scatter plot suggests a relationship (Sample problem: Create a scatter plot to compare the lengths of the bases of several similar triangles with their areas.);
- ☐ **8m78** **SQC2005** – make inferences and convincing arguments that are based on the analysis of charts, tables, and graphs (Sample problem: Use data to make a convincing argument that the environment is becoming increasingly polluted.);
- ☐ **8m79** **SQC2005** – compare two attributes or characteristics, using a variety of data management tools and strategies (i.e., pose a relevant question, then design an experiment or survey, collect and analyse the data, and draw conclusions) (Sample problem: Compare the length and width of different-sized leaves from a maple tree to determine if maple leaves grow proportionally. What generalizations can you make?).

Probability

- ☐ **8m80** **SQC2005** – compare, through investigation, the theoretical probability of an event (i.e., the ratio of the number of ways a favourable outcome can occur compared to the total number of possible outcomes) with experimental probability, and explain why they might differ (Sample problem:Toss a fair coin 10 times, record the results, and explain why you might not get the predicted result of 5 heads and 5 tails.);
- ☐ **8m81** **SQC2005** – determine, through investigation, the tendency of experimental probability to approach theoretical probability as the number of trials in an experiment increases, using class-generated data and technology-based simulation models (Sample problem: Compare the theoretical probability of getting a 6 when tossing a number cube with the experimental probabilities obtained after tossing a number cube once, 10 times, 100 times, and 1000 times.);
- ☐ **8m82** **SQC2005** – identify the complementary event for a given event, and calculate the theoretical probability that a given event will not occur (Sample problem: Bingo uses the numbers from 1 to 75. If the numbers are pulled at random, what is the probability that the first number is a multiple of 5? is not a multiple of 5?).

Gr.12 Foundations for College Mathematics---A. MATHEMATICAL MODELS MAP 4C

1. Solving Exponential Equations

- ☐ **MM1.02** **CR2007** 1.2 simplify algebraic expressions containing integer exponents using the laws of exponents Sample problem: Simplify $(a^2b^5c^5)/ab^{-3}c^4$ and evaluate for a= 8, b= 2, and c=–30.
- ☐ **MM1.03** **CR2007** 1.3 determine, through investigation using a variety of tools (e.g., calculator, paper and pencil, graphing technology) and strategies (e.g., patterning; finding values from a graph; interpreting the exponent laws), the value of a power with a rational exponent (i.e., $x^{m/n}$, where x > 0 and m and n are integers) Sample problem: The exponent laws suggest that $4^{1/2} \times 4^{1/2} = 4^1$. What value would you assign to $4^{1/2}$? What value would you assign to $27^{1/3}$? Explain your reasoning. Extend your reasoning to make a generalization about the meaning of $x^{1/n}$, where x > 0 and n is a natural number.

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- ☐ **MM1.05 CR2007** 1.5 solve simple exponential equations numerically and graphically, with technology (e.g., use systematic trial with a scientific calculator to determine the solution to the equation $1.05^x = 1.276$), and recognize that the solutions may not be exact Sample problem: Use the graph of $y = 3^x$ to solve the equation $3^x = 5$.
- ☐ **MM1.06 CR2007** 1.6 solve problems involving exponential equations arising from real-world applications by using a graph or table of values generated with technology from a given equation [e.g., $h = 2(0.6)^n$, where h represents the height of a bouncing ball and n represents the number of bounces] Sample problem: Dye is injected to test pancreas function. The mass, Rgrams, of dye remaining in a healthy pancreas after t minutes is given by the equation $R = I(0.96)^t$, where I grams is the mass of dye initially injected. If 0.50 g of dye is initially injected into a healthy pancreas, determine how much time elapses until 0.35 g remains by using a graph and/or table of values generated with technology. *The knowledge and skills described in this expectation are to be introduced as needed, and applied and consolidated, where appropriate, throughout the course.
- ☐ **MM1.07 CR2007** 1.7 solve exponential equations in one variable by determining a common base (e.g., $2^x = 32$, $4^{5x-1} = 2^{2(x+11)}$, $3^{5x+8} = 27^x$) Sample problem: Solve $3^{5x+8} = 27^x$ by determining a common base, verify by substitution, and make connections to the intersection of $y = 3^{5x+8}$ and $y = 27^x$ using graphing technology.

2. Modelling Graphically

- ☐ **MM2.02 CR2007** 2.2 describe trends based on given graphs, and use the trends to make predictions or justify decisions (e.g., given a graph of the men's 100-m world record versus the year, predict the world record in the year 2050 and state your assumptions; given a graph showing the rising trend in graduation rates among Aboriginal youth, make predictions about future rates) Sample problem: Given the following graph, describe the trend in Canadian greenhouse gas emissions over the time period shown. Describe some factors that may have influenced these emissions over time. Predict the emissions today, explain your prediction using the graph and possible factors, and verify using current data. Canadian Greenhouse Gas Emissions (graph omitted from page 138) Source: Environment Canada, Greenhouse Gas Inventory 1990-2001, 2003
- ☐ **MM2.05 CR2007** 2.5 compare, through investigation with technology, the graphs of pairs of relations (i.e., linear, quadratic, exponential) by describing the initial conditions and the behaviour of the rates of change (e.g., compare the graphs of amount versus time for equal initial deposits in simple interest and compound interest accounts) Sample problem: In two colonies of bacteria, the population doubles every hour. The initial population of one colony is twice the initial population of the other. How do the graphs of population versus time compare for the two colonies? How would the graphs change if the population tripled every hour, instead of doubling?
- ☐ **MM2.06 CR2007** 2.6 recognize that a linear model corresponds to a constant increase or decrease over equal intervals and that an exponential model corresponds to a constant percentage increase or decrease over equal intervals, select a model (i.e., linear, quadratic, exponential) to represent the relationship between numerical data graphically and algebraically, using a variety of tools (e.g., graphing technology) and strategies (e.g., finite differences, regression), and solve related problems Sample problem: Given the data table at the top of page 139, determine an algebraic model to represent the relationship between population and time, using technology. Use the algebraic model to predict the population in 2015, and describe any assumptions made. Years after 1955 | Population of Geese 0 | 5 000, 10 | 12 000, 20 | 26 000, 30 | 62 000, 40 | 142 000, 50 | 260 000

3. Modelling Algebraically

- ☐ **MM3.02 CR2007** 3.2 determine the value of a variable of degree no higher than three, using a formula drawn from an application, by first substituting known values and then solving for the variable, and by first isolating the variable and then substituting known values Sample problem: Use the formula $V = 4/3\pi r^3$ to determine the radius of a sphere with a volume of 1000 cm^3.
- ☐ **MM3.03 CR2007** 3.3 make connections between formulas and linear, quadratic, and exponential functions [e.g., recognize that the compound interest formula, $A = P(1 + i)^n$, is an example of an exponential function A(n) when P and i are constant, and of a linear function A(P) when i and n are constant], using a variety of tools and strategies (e.g., comparing the graphs generated with technology when different variables in a formula are set as constants) Sample problem: Which variable(s) in the formula $V = \pi r^2 h$ would you need to set as a constant to generate a linear equation? A quadratic equation? Explain why you can expect the relationship between the volume and the height to be linear when the radius is constant.

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Gr.12 Foundations for College Mathematics---B. PERSONAL FINANCE MAP 4C

1. Understanding Annuities

- ☐ **PE1.02 CR2007** 1.2 determine, through investigation using technology (e.g., the TVM Solver on a graphing calculator; online tools), the effects of changing the conditions (i.e., the payments, the frequency of the payments, the interest rate, the compounding period) of an ordinary simple annuity (i.e., an annuity in which payments are made at the end of each period, and compounding and payment periods are the same) (e.g., long-term savings plans, loans) Sample problem: Given an ordinary simple annuity with semi-annual deposits of $1000, earning 6% interest per year compounded semi-annually, over a 20-year term, which of the following results in the greatest return: doubling the payments, doubling the interest rate, doubling the frequency of the payments and the compounding, or doubling the payment and compounding period?
- ☐ **PE1.03 CR2007** 1.3 solve problems, using technology (e.g., scientific calculator, spreadsheet, graphing calculator), that involve the amount, the present value, and the regular payment of an ordinary simple annuity Sample problem: Using a spreadsheet, calculate the total interest paid over the life of a $10 000 loan with monthly repayments over 2 years at 8% per year compounded monthly, and compare the total interest with the original principal of the loan.
- ☐ **PE1.04 CR2007** 1.4 demonstrate, through investigation using technology (e.g., a TVM Solver), the advantages of starting deposits earlier when investing in annuities used as long-term savings plans Sample problem: If you want to have a million dollars at age 65, how much would you have to contribute monthly into an investment that pays 7% per annum, compounded monthly, beginning at age 20? At age 35? At age 50?
- ☐ **PE1.06 CR2007** 1.6 read and interpret an amortization table for a mortgage Sample problem: You purchase a $200 000 condominium with a $25 000 down payment, and you mortgage the balance at 6.5% per year compounded semi-annually over 25 years, payable monthly. Use a given amortization table to compare the interest paid in the first year of the mortgage with the interest paid in the 25th year.
- ☐ **PE1.08 CR2007** 1.8 determine, through investigation using technology (e.g., TVM Solver, online tools, financial software), the effects of varying payment periods, regular payments, and interest rates on the length of time needed to pay off a mortgage and on the total interest paid Sample problem: Calculate the interest saved on a $100 000 mortgage with monthly payments, at 6% per annum compounded semi-annually, when it is amortized over 20 years instead of 25 years.

2. Renting or Owning Accommodation

- ☐ **PE2.03 CR2007** 2.3 solve problems, using technology (e.g., calculator, spreadsheet), that involve the fixed costs (e.g., mortgage, insurance, property tax) and variable costs (e.g., maintenance, utilities) of owning or renting accommodation Sample problem: Calculate the total of the fixed and variable monthly costs that are associated with owning a detached house but that are usually included in the rent for rental accommodation.

3. Designing Budgets

- ☐ **PE3.04 CR2007** 3.4 identify and describe the factors to be considered in determining the affordability of accommodation in the local community (e.g., income, long-term savings, number of dependants, non-discretionary expenses), and consider the affordability of accommodation under given circumstances Sample problem: Determine, through investigation, if it is possible to change from renting to owning accommodation in your community in five years if you currently earn $30 000 per year, pay $900 per month in rent, and have savings of $20 000.

Gr.12 Foundations for College Mathematics---C. GEOMETRY AND TRIGONOMETRY MAP 4C

1. Solving Problems Involving Measurement and Geometry

- ☐ **GT1.02 CR2007** 1.2 solve problems involving the areas of rectangles, triangles, and circles, and of related composite shapes, in situations arising from real-world applications Sample problem: A car manufacturer wants to display three of its compact models in a triangular arrangement on a rotating circular platform. Calculate a reasonable area for this platform, and explain your assumptions and reasoning.

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within: **Mathematics**

- ☐ **GT1.03** **CR2007** 1.3 solve problems involving the volumes and surface areas of rectangular prisms, triangular prisms, and cylinders, and of related composite figures, in situations arising from real-world applications Sample problem: Compare the volumes of concrete needed to build three steps that are 4 ft wide and that have the cross-sections shown below. Explain your assumptions and reasoning. (omitted graph from page 142)

2. Investigating Optimal Dimensions

- ☐ **GT2.01** **CR2007** 2.1 recognize, through investigation using a variety of tools (e.g., calculators; dynamic geometry software; manipulatives such as tiles, geoboards, toothpicks) and strategies (e.g., modelling; making a table of values; graphing), and explain the significance of optimal perimeter, area, surface area, and volume in various applications (e.g., the minimum amount of packaging material, the relationship between surface area and heat loss) Sample problem: You are building a deck attached to the second floor of a cottage, as shown below. Investigate how perimeter varies with different dimensions if you build the deck using exactly 48 1-m x 1-m decking sections, and how area varies if you use exactly 30 m of deck railing. Note: the entire outside edge of the deck will be railed. (omitted graph from page 142)
- ☐ **GT2.02** **CR2007** 2.2 determine, through investigation using a variety of tools (e.g., calculators, dynamic geometry software, manipulatives) and strategies (e.g., modelling; making a table of values; graphing), the optimal dimensions of a two-dimensional shape in metric or imperial units for a given constraint (e.g., the dimensions that give the minimum perimeter for a given area) Sample problem: You are constructing a rectangular deck against your house. You will use 32 ft of railing and will leave a 4-ft gap in the railing for access to stairs. Determine the dimensions that will maximize the area of the deck.
- ☐ **GT2.03** **CR2007** 2.3 determine, through investigation using a variety of tools and strategies (e.g., modelling with manipulatives; making a table of values; graphing), the optimal dimensions of a right rectangular prism, a right triangular prism, and a right cylinder in metric or imperial units for a given constraint (e.g., the dimensions that give the maximum volume for a given surface area) Sample problem: Use a table of values and a graph to investigate the dimensions of a rectangular prism, a triangular prism, and a cylinder that each have a volume of 64 cm3 and the minimum surface area

3. Solving Problems Involving Trigonometry

- ☐ **GT3.04** **CR2007** 3.4 solve problems involving oblique triangles, including those that arise from real-world applications, using the sine law (in non-ambiguous cases only) and the cosine law, and using metric or imperial units Sample problem: A plumber must cut a piece of pipe to fit from A to B. Determine the length of the pipe. (omitted graph from page 143)
- ☐ **GT3.05** **CR2007** 3.5 gather, interpret, and describe information about applications of trigonometry in occupations, and about college programs that explore these applications Sample problem: Prepare a presentation to showcase an occupation that makes use of trigonometry, to describe the education and training needed for the occupation, and to highlight a particular use of trigonometry in the occupation.

Gr.12 Foundations for College Mathematics---D. DATA MANAGEMENT MAP 4C

1. Working With Two-Variable Data

- ☐ **DM1.01** **CR2007** 1.1 distinguish situations requiring one-variable and two-variable data analysis, describe the associated numerical summaries (e.g., tally charts, summary tables) and graphical summaries (e.g., bar graphs, scatter plots), and recognize questions that each type of analysis addresses (e.g., What is the frequency of a particular trait in a population? What is the mathematical relationship between two variables?) Sample problem: Given a table showing shoe size and height for several people, pose a question that would require one-variable analysis and a question that would require two-variable analysis of the data.
- ☐ **DM1.03** **CR2007** 1.3 collect two-variable data from primary sources, through experimentation involving observation or measurement, or from secondary sources (e.g., Internet databases, newspapers, magazines), and organize and store the data using a variety of tools (e.g., spreadsheets, dynamic statistical software) Sample problem: Download census data from Statistics Canada on age and average income, store the data using dynamic statistics software, and organize the data in a summary table.

2. Applying Data Management

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FIND RESULTS: 418 expectations were found
containing the term(s): **"sample problem"**
within: **Gr.7, Gr.8, Gr.9, Gr.10, Gr.11, Gr.12**
within: **Mathematics**

- ☐ **DM2.02** **CR2007** 2.2 describe examples of indices used by the media (e.g., consumer price index, S&P/TSX composite index, new housing price index) and solve problems by interpreting and using indices (e.g., by using the consumer price index to calculate the annual inflation rate) Sample problem: Use the new housing price index on E-STAT to track the cost of purchasing a new home over the past 10 years in the Toronto area, and compare with the cost in Calgary, Charlottetown, and Vancouver over the same period. Predict how much a new home that today costs $200 000 in each of these cities will cost in 5 years.

- ☐ **DM2.04** **CR2007** 2.4 assess the validity of conclusions presented in the media by examining sources of data, including Internet sources (i.e., to determine whether they are authoritative, reliable, unbiased, and current), methods of data collection, and possible sources of bias (e.g.,sampling bias, non-response bias, a bias in a survey question), and by questioning the analysis of the data (e.g., whether there is any indication of the sample size in the analysis) and conclusions drawn from the data (e.g., whether any assumptions are made about cause and effect) Sample problem: The headline that accompanies the following graph says “Big Increase in Profits”. Suggest reasons why this headline may or may not be true.

Gr.11   Foundations for College Mathematics---Mathematical Models   MBF 3C

Connecting Graphs and Equations of Quadratic Relations

- ☐ **MM1.02** **CR2006** – determine and interpret meaningful values of the variables, given a graph of a quadratic relation arising from a real-world application (Sample problem: Under certain conditions, there is a quadratic relation between the profit of a manufacturing company and the number of items it produces. Explain how you could interpret a graph of the relation to determine the numbers of items produced for which the company makes a profit and to determine the maximum profit the company can make.);
- ☐ **MM1.03** **CR2006** – determine, through investigation using technology, and describe the roles of a, h, and k in quadratic relations of the form $y = a(x - h)^2 + k$ in terms of transformations on the graph of $y = x^2$ (i.e., translations; reflections in the x-axis; vertical stretches and compressions) [Sample problem: Investigate the graph $y = 3(x - h)^2 + 5$ for various values of h, using technology, and describe the effects of changing h in terms of a transformation.];
- ☐ **MM1.06** **CR2006** – express the equation of a quadratic relation in the standard form $y = ax^2 + bx + c$, given the vertex form $y = a(x - h)^2 + k$, and verify, using graphing technology, that these forms are equivalent representations [Sample problem: Given the vertex form $y = 3(x - 1)^2 + 4$, express the equation in standard form. Use technology to compare the graphs of these two forms of the equation.];
- ☐ **MM1.08** **CR2006** – determine, through investigation, and describe the connection between the factors of a quadratic expression and the x-intercepts of the graph of the corresponding quadratic relation (Sample problem: Investigate the relationship between the factored form of $3x^2 + 15x + 12$ and the x-intercepts of $y = 3x^2 + 15x + 12$.);
- ☐ **MM1.09** **CR2006** – solve problems, using an appropriate strategy (i.e., factoring, graphing), given equations of quadratic relations, including those that arise from real-world applications (e.g., break-even point) (Sample problem: On planet X, the height, h metres, of an object fired upward from the ground at 48 m/s is described by the equation $h = 48t - 16t^2$, where t seconds is the time since the object was fired upward. Determine the maximum height of the object, the times at which the object is 32 m above the ground, and the time at which the object hits the ground.).

Connecting Graphs and Equations of Exponential Relations

- ☐ **MM2.06** **CR2006** – distinguish exponential relations from linear and quadratic relations by making comparisons in a variety of ways (e.g., comparing rates of change using finite differences in tables of values; inspecting graphs; comparing equations), within the same context when possible (e.g., simple interest and compound interest; population growth) (Sample problem: Explain in a variety of ways how you can distinguish exponential growth represented by $y = 2^x$ from quadratic growth represented by $y = x^2$ and linear growth represented by $y = 2x$.).

Solving Problems Involving Exponential Relations

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within: **Gr.7, Gr.8, Gr.9, Gr.10, Gr.11, Gr.12**
within: **Mathematics**

- ☐ **MM3.01 CR2006** – collect data that can be modelled as an exponential relation, through investigation with and without technology, from primary sources, using a variety of tools (e.g., concrete materials such as number cubes, coins; measurement tools such as electronic probes), or from secondary sources (e.g.,websites such as Statistics Canada, E-STAT), and graph the data (Sample problem: Collect data and graph the cooling curve representing the relationship between temperature and time for hot water cooling in a porcelain mug. Predict the shape of the cooling curve when hot water cools in an insulated mug.Test your prediction.);
- ☐ **MM3.03 CR2006** – pose and solve problems involving exponential relations arising from a variety of real-world applications (e.g., population growth, radioactive decay, compound interest) by using a given graph or a graph generated with technology from a given equation (Sample problem: Given a graph of the population of a bacterial colony versus time, determine the change in population in the first hour.);
- ☐ **MM3.04 CR2006** – solve problems using given equations of exponential relations arising from a variety of real-world applications (e.g., radioactive decay, population growth, height of a bouncing ball, compound interest) by substituting values for the exponent into the equations (Sample problem: The height, h metres, of a ball after n bounces is given by the equation $h = 2(0.6)^n$. Determine the height of the ball after 3 bounces.).

Gr.11 Foundations for College Mathematics---Personal Finance MBF 3C

Solving Problems Involving Compound Interest

- ☐ **PF1.01 CR2006** – determine, through investigation using technology, the compound interest for a given investment, using repeated calculations of simple interest, and compare, using a table of values and graphs, the simple and compound interest earned for a given principal (i.e., investment) and a fixed interest rate over time (Sample problem: Compare, using tables of values and graphs, the amounts after each of the first five years for a $1000 investment at 5% simple interest per annum and a $1000 investment at 5% interest per annum, compounded annually.);
- ☐ **PF1.03 CR2006** – solve problems, using a scientific calculator, that involve the calculation of the amount, A (also referred to as future value, FV), and the principal, P (also referred to as present value, PV), using the compound interest formula in the form $A = P(1 + i)^n$ [or $FV = PV (1 + i)^n$] (Sample problem: Calculate the amount if $1000 is invested for 3 years at 6% per annum, compounded quarterly.);
- ☐ **PF1.05 CR2006** – solve problems, using a TVM Solver in a graphing calculator or on a website, that involve the calculation of the interest rate per compounding period, i, or the number of compounding periods, n, in the compound interest formula $A = P(1 + i)^n$ [or $FV = PV (1 + i)^n$] (Sample problem: Use the TVM Solver in a graphing calculator to determine the time it takes to double an investment in an account that pays interest of 4% per annum, compounded semi-annually.);
- ☐ **PF1.06 CR2006** – determine, through investigation using technology (e.g., a TVM Solver in a graphing calculator or on a website), the effect on the future value of a compound interest investment or loan of changing the total length of time, the interest rate, or the compounding period (Sample problem: Investigate whether doubling the interest rate will halve the time it takes for an investment to double.).

Comparing Financial Services

- ☐ **PF2.05 CR2006** – solve problems involving applications of the compound interest formula to determine the cost of making a purchase on credit (Sample problem: Using information gathered about the interest rates and regulations for two different credit cards, compare the costs of purchasing a $1500 computer with each card if the full amount is paid 55 days later.).

Owning and Operating a Vehicle

- ☐ **PF3.01 CR2006** – gather and interpret information about the procedures and costs involved in insuring a vehicle (e.g., car, motorcycle, snowmobile) and the factors affecting insurance rates (e.g., gender, age, driving record, model of vehicle, use of vehicle), and compare the insurance costs for different categories of drivers and for different vehicles (Sample problem: Use automobile insurance websites to investigate the degree to which the type of car and the age and gender of the driver affect insurance rates.);
- ☐ **PF3.02 CR2006** – gather, interpret, and compare information about the procedures and costs (e.g., monthly payments, insurance, depreciation, maintenance, miscellaneous expenses) involved in buying or leasing a new vehicle or buying a used vehicle (Sample problem: Compare the costs of buying a new car, leasing the same car, and buying an older model of the same car.);

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within: **Mathematics**

☐ **PF3.03** **CR2006** – solve problems, using technology (e.g., calculator, spreadsheet), that involve the fixed costs (e.g., licence fee, insurance) and variable costs (e.g., maintenance, fuel) of owning and operating a vehicle (Sample problem: The rate at which a car consumes gasoline depends on the speed of the car. Use a given graph of gasoline consumption, in litres per 100 km, versus speed, in kilometres per hour, to determine how much gasoline is used to drive 500 km at speeds of 80 km/h, 100 km/h, and 120 km/h. Use the current price of gasoline to calculate the cost of driving 500 km at each of these speeds.).

Gr.11 Foundations for College Mathematics---Geometry and Trigonometry MBF 3C

Representing Two-Dimensional Shapes and Three-Dimensional Figures

☐ **GT1.01** **CR2006** – identify real-world applications of geometric shapes and figures, through investigation (e.g., by importing digital photos into dynamic geometry software), in a variety of contexts (e.g., product design, architecture, fashion), and explain these applications (e.g., one reason that sewer covers are round is to prevent them from falling into the sewer during removal and replacement) (Sample problem: Explain why rectangular prisms are used for packaging many products.);

☐ **GT1.04** **CR2006** – solve design problems that satisfy given constraints (e.g., design a rectangular berm that would contain all the oil that could leak from a cylindrical storage tank of a given height and radius), using physical models (e.g., built from popsicle sticks, cardboard, duct tape) or drawings (e.g., made using design or drawing software), and state any assumptions made (Sample problem: Design and construct a model boat that can carry the most pennies, using one sheet of 8.5 in x 11 in card stock, no more than five popsicle sticks, and some adhesive tape or glue.).

Gr.11 Foundations for College Mathematics---Data Management MBF 3C

Working With One-Variable Data

☐ **DM1.01** **CR2006** – identify situations involving one-variable data (i.e., data about the frequency of a given occurrence), and design questionnaires (e.g., for a store to determine which CDs to stock; for a radio station to choose which music to play) or experiments (e.g., counting, taking measurements) for gathering one-variable data, giving consideration to ethics, privacy, the need for honest responses, and possible sources of bias (Sample problem: One lane of a three-lane highway is being restricted to vehicles with at least two passengers to reduce traffic congestion. Design an experiment to collect one-variable data to decide whether traffic congestion is actually reduced.);

☐ **DM1.03** **CR2006** – explain the distinction between the terms population and sample, describe the characteristics of a good sample, and explain why sampling is necessary (e.g., time, cost, or physical constraints) (Sample problem: Explain the terms sample and population by giving examples within your school and your community.);

☐ **DM1.08** **CR2006** – explain the appropriate use of measures of central tendency (i.e., mean, median, mode) and measures of spread (i.e., range, standard deviation) (Sample problem: Explain whether the mean or the median of your course marks would be the more appropriate representation of your achievement. Describe the additional information that the standard deviation of your course marks would provide.);

☐ **DM1.09** **CR2006** – compare two or more sets of one-variable data, using measures of central tendency and measures of spread (Sample problem: Use measures of central tendency and measures of spread to compare data that show the lifetime of an economy light bulb with data that show the lifetime of a long-life light bulb.);

Applying Probability

☐ **DM2.04** **CR2006** – compare, through investigation, the theoretical probability of an event with the experimental probability, and explain why they might differ (Sample problem: If you toss 10 coins repeatedly, explain why 5 heads are unlikely to result from every toss.);

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within: **Mathematics**

- ☐ **DM2.05** **CR2006** – determine, through investigation using class-generated data and technology-based simulation models (e.g., using a random-number generator on a spreadsheet or on a graphing calculator), the tendency of experimental probability to approach theoretical probability as the number of trials in an experiment increases (e.g.,?If I simulate tossing a coin 1000 times using technology, the experimental probability that I calculate for tossing tails is likely to be closer to the theoretical probability than if I only simulate tossing the coin 10 times?) (Sample problem: Calculate the theoretical probability of rolling a 2 on a number cube. Simulate rolling a number cube, and use the simulation to calculate the experimental probability of rolling a 2 after 10, 20, 30, ..., 200 trials. Graph the experimental probability versus the number of trials, and describe any trend.);

Gr.11 Functions and Applications---Quadratic Functions MCF 3M

Solving Quadratic Equations

- ☐ **QF1.03** **CR2006** – factor quadratic expressions in one variable, including those for which $a\neq1$ (e.g., $3x^2 + 13x - 10$), differences of squares (e.g., $4x^2 - 25$), and perfect square trinomials (e.g., $9x^2 + 24x + 16$), by selecting and applying an appropriate strategy (Sample problem: Factor $2x^2 - 12x + 10$.);*
- ☐ **QF1.05** **CR2006** – determine, through investigation, and describe the connection between the factors used in solving a quadratic equation and the x-intercepts of the corresponding quadratic relation (Sample problem: The profit, P, of a video company, in thousands of dollars, is given by $P = -5x^2 + 550x - 5000$, where x is the amount spent on advertising, in thousands of dollars. Determine, by factoring and by graphing, the amount spent on advertising that will result in a profit of $0. Describe the connection between the two strategies.);
- ☐ **QF1.08** **CR2006** – determine the real roots of a variety of quadratic equations (e.g., $100x^2 = 115x + 35$), and describe the advantages and disadvantages of each strategy (i.e., graphing; factoring; using the quadratic formula) (Sample problem: Generate 10 quadratic equations by randomly selecting integer values for a, b,and c in $ax^2+ bx + c = 0$. Solve the equations using the quadratic formula. How many of the equations could you solve by factoring?).

Connecting Graphs and Equations of Quadratic Functions

- ☐ **QF2.01** **CR2006** – explain the meaning of the term function, and distinguish a function from a relation that is not a function, through investigation of linear and quadratic relations using a variety of representations (i.e., tables of values, mapping diagrams, graphs, function machines, equations) and strategies (e.g., using the vertical line test) (Sample problem: Investigate, using numeric and graphical representations, whether the relation $x = y^2$ is a function, and justify your reasoning.);
- ☐ **QF2.02** **CR2006** – substitute into and evaluate linear and quadratic functions represented using function notation [e.g., evaluate f (1/2), given $f(x) = 2x^2 + 3x-1$], including functions arising from real-world applications [Sample problem: The relationship between the selling price of a sleeping bag, s dollars, and the revenue at that selling price, r(s) dollars, is represented by the function $r(s) = -10s^2 + 1500s$. Evaluate, interpret, and compare r (29.95), r (60.00), r (75.00), r (90.00),and r (130.00).];
- ☐ **QF2.04** **CR2006** – explain any restrictions on the domain and the range of a quadratic function in contexts arising from real-world applications (Sample problem: A quadratic function represents the relationship between the height of a ball and the time elapsed since the ball was thrown.What physical factors will restrict the domain and range of the quadratic function?);
- ☐ **QF2.05** **CR2006** – determine, through investigation using technology, and describe the roles of a, h,and k in quadratic functions of the form $f(x) = a(x- h)^2 + k$ in terms of transformations on the graph of $f(x) = x^2$ (i.e., translations; reflections in the x-axis; vertical stretches and compressions) [Sample problem: Investigate the graph $f(x) = 3(x- h)^2 + 5$ for various values of h, using technology, and describe the effects of changing h in terms of a transformation.];
- ☐ **QF2.06** **CR2006** – sketch graphs of $g(x) = a(x- h)^2 + k$ by applying one or more transformations to the graph of $f(x) = x^2$ [Sample problem: Transform the graph of $f(x) = x^2$ to sketch the graphs of $g(x) = x^2 - 4$ and $h(x) = -2(x + 1)^2$.];
- ☐ **QF2.07** **CR2006** – express the equation of a quadratic function in the standard form $f(x) = ax^2+ bx + c$, given the vertex form $f(x) = a(x- h)^2 + k$, and verify, using graphing technology, that these forms are equivalent representations [Sample problem: Given the vertex form $f(x) = 3(x-1)^2 + 4$, express the equation in standard form. Use technology to compare the graphs of these two forms of the equation.];

FIND RESULTS: 418 expectations were found
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within: **Mathematics**

Solving Problems Involving Quadratic Functions

- ☐ **QF3.01** **CR2006** – collect data that can be modelled as a quadratic function, through investigation with and without technology, from primary sources, using a variety of tools (e.g., concrete materials; measurement tools such as measuring tapes, electronic probes, motion sensors), or from secondary sources (e.g., websites such as Statistics Canada, E-STAT), and graph the data (Sample problem: When a 3 x 3 x 3 cube made up of 1 x 1 x 1 cubes is dipped into red paint, 6 of the smaller cubes will have 1 face painted. Investigate the number of smaller cubes with 1 face painted as a function of the edge length of the larger cube, and graph the function.);
- ☐ **QF3.03** **CR2006** – solve problems arising from real-world applications, given the algebraic representation of a quadratic function (e.g., given the equation of a quadratic function representing the height of a ball over elapsed time, answer questions that involve the maximum height of the ball, the length of time needed for the ball to touch the ground, and the time interval when the ball is higher than a given measurement) [Sample problem: In a DC electrical circuit, the relationship between the power used by a device, P (in watts, W), the electric potential difference (voltage), V (in volts,V), the current, I (in amperes, A), and the resistance, R (in ohms, Ω), is represented by the formula $P = IV - I^2R$. Represent graphically and algebraically the relationship between the power and the current when the electric potential difference is 24 V and the resistance is 1.5 Ω. Determine the current needed in order for the device to use the maximum amount of power.]. (Graphic on page 46 omitted)

Gr.11   Functions and Applications---Exponential Functions   MCF 3M

Connecting Graphs and Equations Exponential Functions

- ☐ **EF1.01** **CR2006** – determine, through investigation using avariety of tools (e.g., calculator, paper and pencil, graphing technology) and strategies (e.g., patterning; finding values from a graph; interpreting the exponent laws), the value of a power with a rational exponent (i.e.,x,where x>0 and m and n are integers) (Sample problem:The exponent laws suggest that $4^{1/2} \times 4^{1/2} = 4^1$. What value would you assign to $4^{1/2}$? What value would you assign to $27^{1/3}$? Explain your reasoning. Extend your reasoning to make a generalization about the meaning of $x^{1/n}$, where x > 0 and n is a natural number.);
- ☐ **EF1.04** **CR2006** – determine, through investigation, and describekey properties relating to domain and range, intercepts, increasing/decreasing intervals, and asymptotes (e.g., the domain is the set of real numbers; the range is the set of positive real numbers; the function either increases or decreases throughout its domain) for exponential functions represented in avariety of ways [e.g., tables of values, mapping diagrams, graphs, equations of the form f(x) = ax(a > 0, a ≠1), function machines] [Sample problem:Graph $f(x) = 2^x$, $g(x) = 3^x$, and $h(x) = 0.5^x$ on the same set of axes. Make comparisons between the graphs, and explain the relationship between the y-intercepts.];
- ☐ **EF1.06** **CR2006** – distinguish exponential functions from linear and quadratic functions by making comparisons in a variety of ways (e.g., comparing rates of change using finite differences in tables of values; identifying a constant ratio in a table of values; inspecting graphs; comparing equations), within the same context when possible (e.g., simple interest and compound interest; population growth) [Sample problem: Explain in a variety of ways how you can distinguish the exponential function $f(x) = 2^x$ from the quadratic function $f(x) = x^2$ and the linear function f(x) = 2x.].

Solving Problems Involving Exponential Functions

- ☐ **EF2.01** **CR2006** – collect data that can be modelled as an exponential function, through investigation with and without technology, from primary sources, using a variety of tools (e.g., concrete materials such as number cubes, coins; measurement tools such as electronic probes), or from secondary sources (e.g., websites such as Statistics Canada, E-STAT), and graph the data (Sample problem: Collect data and graph the cooling curve representing the relationship between temperature and time for hot water cooling in a porcelain mug. Predict the shape of the cooling curve when hot water cools in an insulated mug. Test your prediction.);

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within: **Mathematics**

- ☐ **EF2.03** **CR2006** – solve problems using given graphs or equations of exponential functions arising from a variety of real-world applications (e.g., radioactive decay, population growth, height of a bouncing ball, compound interest) by interpreting the graphs or by substituting values for the exponent into the equations [Sample problem: The temperature of a cooling liquid over time can be modelled by the exponential function $T(x) = 60\ (1/2)^{x/30} + 20$, where T(x) is the temperature, in degrees Celsius, and x is the elapsed time, in minutes. Graph the function and determine how long it takes for the temperature to reach 28°C.].

Solving Financial Problems Involving Exponential Functions

- ☐ **EF3.01** **CR2006** – compare, using a table of values and graphs, the simple and compound interest earned for a given principal (i.e., investment) and a fixed interest rate over time (Sample problem: Compare, using tables of values and graphs, the amounts after each of the first five years for a $1000 investment at 5% simple interest per annum and a $1000 investment at 5% interest per annum, compounded annually.);
- ☐ **EF3.02** **CR2006** – solve problems, using a scientific calculator, that involve the calculation of the amount, A (also referred to as future value, FV), and the principal, P (also referred to as present value, PV), using the compound interest formula in the form $A = P(1 + i)^n$ [or $FV = PV(1 + i)^n$](Sample problem: Calculate the amount if $1000 is invested for three years at 6% per annum, compounded quarterly.);
- ☐ **EF3.03** **CR2006** – determine, through investigation (e.g., using spreadsheets and graphs), that compound interest is an example of exponential growth [e.g., the formulas for compound interest, $A = P(1 + i)^n$, and present value, $PV = A(1 + i)^{-n}$, are exponential functions, where the number of compounding periods, n, varies] [Sample problem: Describe an investment that could be represented by the function $f(x) = 500(1.01)^x$];
- ☐ **EF3.04** **CR2006** – solve problems, using a TVM Solver in a graphing calculator or on a website, that involve the calculation of the interest rate per compounding period, i, or the number of compounding periods, n, in the compound interest formula $A = P(1 + i)^n$ [or $FV = PV(1 + i)^n$],(Sample problem: Use the TVM Solver in a graphing calculator to determine the time it takes to double an investment in an account that pays interest of 4% per annum, compounded semi-annually.);
- ☐ **EF3.06** **CR2006** – determine, through investigation using technology (e.g., the TVM Solver in a graphing calculator; online tools), the effects of changing the conditions (i.e., the payments, the frequency of the payments, the interest rate, the compounding period) of ordinary annuities in situations where the compounding period and the payment period are the same (e.g., long-term savings plans, loans) (Sample problem: Compare the amounts at age 65 that would result from making an annual deposit of $1000 starting at age 20, or from making an annual deposit of $3000 starting at age 50, to an RRSP that earns 6% interest per annum, compounded annually. What is the total of the deposits in each situation?);

Gr.11 Functions and Applications---Trigonometric Functions MCF 3M

Applying the Sine Law and the Cosine Law in Acute Triangles

- ☐ **TF1.02** **CR2006** – solve problems involving two right triangles in two dimensions (Sample problem: A helicopter hovers 500 m above a long straight road. Ahead of the helicopter on the road are two trucks. The angles of depression of the two trucks from the helicopter are 60° and 20°. How far apart are the two trucks?);

Connecting Graphs and Equations of Sine Functions

- ☐ **TF2.05** **CR2006** – make connections, through investigation with technology, between changes in a real-world situation that can be modelled using a periodic function and transformations of the corresponding graph (e.g., investigating the connection between variables for a swimmer swimming lengths of a pool and transformations of the graph of distance from the starting point versus time) (Sample problem: Generate a sine curve by walking a circle of two-metre diameter in front of a motion sensor. Describe how the following changes in the motion change the graph: starting at a different point on the circle; starting a greater distance from the motion sensor; changing direction; increasing the radius of the circle; and increasing the speed);
- ☐ **TF2.07** **CR2006** – sketch graphs of f(x) = a sinx, f(x) = sinx + c, and f(x) = sin(x - d) by applying transformations to the graph of f (x) = sinx, and state the domain and range of the transformed functions [Sample problem: Transform the graph of f(x) = sinx to sketch the graphs of g(x) = -2sinx and h(x) = sin(x - 180°), and state the domain and range of each function.].

Solving Problems Involving Sine Functions

FIND RESULTS: 418 expectations were found
containing the term(s): **"sample problem"**
within: **Gr.7, Gr.8, Gr.9, Gr.10, Gr.11, Gr.12**
within: **Mathematics**

- ☐ **TF3.01 CR2006** – collect data that can be modelled as a sine function (e.g., voltage in an AC circuit, sound waves), through investigation with and without technology, from primary sources, using a variety of tools (e.g., concrete materials; measurement tools such as motion sensors), or from secondary sources (e.g., websites such as Statistics Canada, E-STAT), and graph the data (Sample problem: Measure and record distance-time data for a swinging pendulum, using a motion sensor or other measurement tools, and graph the data.);
- ☐ **TF3.03 CR2006** – pose and solve problems based on applications involving a sine function by using a given graph or a graph generated with technology from its equation [Sample problem: The height above the ground of a rider on a Ferris wheel can be modelled by the sine function $h(x) = 25\sin(x - 90°) + 27$, where $h(x)$ is the height, in metres, and x is the angle, in degrees, that the radius to the rider makes with the horizontal. Graph the function, using graphing technology in degree mode, and determine the maximum and minimum heights of the rider, and the measures of the angle when the height of the rider is 40 m.].

Gr.11 Functions---Characteristics of Functions MCR 3U

Representing Functions

- ☐ **CF1.01 CR2006** – explain the meaning of the term function, and distinguish a function from a relation that is not a function, through investigation of linear and quadratic relations using a variety of representations (i.e., tables of values, mapping diagrams, graphs, function machines, equations) and strategies (e.g., identifying a one-to-one or many-to-one mapping; using the vertical line test) (Sample problem: Investigate, using numeric and graphical representations, whether the relation $x = y^2$ is a function, and justify your reasoning.);
- ☐ **CF1.03 CR2006** – explain the meanings of the terms domain and range, through investigation using numeric, graphical, and algebraic representations of the functions $f(x) = x$, $f(x) = x^2$, $f(x) = \sqrt{x}$,and $f(x) = 1/x$; describe the x domain and range of a function appropriately (e.g., for $y = x^2 + 1$, the domain is the set of real numbers, and the range is $y \le 1$); and explain any restrictions on the domain and range in contexts arising from real-world applications (Sample problem: A quadratic function represents the relationship between the height of a ball and the time elapsed since the ball was thrown. What physical factors will restrict the domain and range of the quadratic function?);
- ☐ **CF1.05 CR2006** – determine the numeric or graphical representation of the inverse of a linear or quadratic function, given the numeric, graphical, or algebraic representation of the function, and make connections, through investigation using a variety of tools (e.g., graphing technology, Mira, tracing paper), between the graph of a function and the graph of its inverse (e.g., the graph of the inverse is the reflection of the graph of the function in the line $y = x$) (Sample problem: Given a graph and a table of values representing population over time, produce a table of values for the inverse and graph the inverse on a new set of axes.);
- ☐ **CF1.06 CR2006** – determine, through investigation, the relationship between the domain and range of a function and the domain and range of the inverse relation, and determine whether or not the inverse relation is a function [Sample problem: Given the graph of $f(x) = x^2$, graph the inverse relation. Compare the domain and range of the function with the domain and range of the inverse relation, and investigate connections to the domain and range of the functions $g(x) = \sqrt{x}$,and $h(x) = -\sqrt{x}$.];
- ☐ **CF1.07 CR2006** – determine, using function notation when appropriate, the algebraic representation of the inverse of a linear or quadratic function, given the algebraic representation of the function [e.g., $f(x) = (x - 2)^2 - 5$],and make connections, through investigation using a variety of tools (e.g., graphing technology, Mira, tracing paper), between the algebraic representations of a function and its inverse (e.g., the inverse of a linear function involves applying the inverse operations in the reverse order) (Sample problem: Given the equations of several linear functions, graph the functions and their inverses, determine the equations of the inverses, and look for patterns that connect the equation of each linear function with the equation of the inverse.);
- ☐ **CF1.08 CR2006** – determine, through investigation using technology, and describe the roles of the parameters a, k, d,and c in functions of the form $y = af(k(x - d)) + c$ in terms of transformations on the graphs of $f(x) = x$, $f(x) = x^2$, $f(x) = \sqrt{x}$,and $f(x) = 1/x$ (i.e., translations; reflections in the axes; vertical and horizontal stretches and compressions) [Sample problem: Investigate the graph $f(x) = 3(x - d)^2 + 5$ for various values of d, using technology, and describe the effects of changing d in terms of a transformation.];

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- ☐ **CF1.09** **CR2006** – sketch graphs of y = af (k(x -d))+ c by applying one or more transformations to the graphs of f (x) = x, f (x) = x^2, f (x) = √x, and f (x) = 1/x , and state the domain and range of the transformed functions [Sample problem: Transform the graph of f (x) to sketch g(x), and state the domain and range of each function, for the following: f (x) = √x , g(x) = √(x - 4); f (x) = 1/x, g(x) = - 1/(x + 1)].

Solving Problems Involving Quadratic Functions

- ☐ **CF2.01** **CR2006** – determine the number of zeros (i.e., x-intercepts) of a quadratic function, using a variety of strategies (e.g., inspecting graphs; factoring; calculating the discriminant) (Sample problem: Investigate, using graphing technology and algebraic techniques, the transformations that affect the number of zeros for a given quadratic function.);
- ☐ **CF2.02** **CR2006** – determine the maximum or minimum value of a quadratic function whose equation is given in the form f (x) = ax^2 + bx + c, using an algebraic method (e.g., completing the square; factoring to determine the zeros and averaging the zeros) [Sample problem: Explain how partially factoring f (x) = $3x^2$ - 6x + 5 into the form f (x) = 3x(x - 2) + 5 helps you determine the minimum of the function.];
- ☐ **CF2.03** **CR2006** – solve problems involving quadratic functions arising from real-world applications and represented using function notation [Sample problem: The profit, P(x),of a video company, in thousands of dollars, is given by P(x) = $-5x^2$ + 550x - 5000, where x is the amount spent on advertising, in thousands of dollars. Determine the maximum profit that the company can make, and the amounts spent on advertising that will result in a profit and that will result in a profit of at least $4 000 000.];
- ☐ **CF2.04** **CR2006** – determine, through investigation, the transformational relationship among the family of quadratic functions that have the same zeros, and determine the algebraic representation of a quadratic function, given the real roots of the corresponding quadratic equation and a point on the function [Sample problem: Determine the equation of the quadratic function that passes through (2, 5) if the roots of the corresponding quadratic equation are 1 +√5 and 1 - √5.];
- ☐ **CF2.05** **CR2006** – solve problems involving the intersection of a linear function and a quadratic function graphically and algebraically (e.g., determining the time when two identical cylindrical water tanks contain equal volumes of water, if one tank is being filled at a constant rate and the other is being emptied through a hole in the bottom) [Sample problem: Determine, through investigation, the equations of the lines that have a slope of 2 and that intersect the quadratic function f (x) = x(6 - x) once; twice; never.].

Determining Equivalent Algebraic Expressions*

- ☐ **CF3.01** **CR2006** – simplify polynomial expressions by adding, subtracting, and multiplying (Sample problem: Write and simplify an expression for the volume of a cube with edge length 2x + 1.);
- ☐ **CF3.03** **CR2006** – simplify rational expressions by adding, subtracting, multiplying, and dividing, and state the restrictions on the variable values (Sample problem: Simplify 2x/$4x^2$+ 6x -3/2x + 3, and state the restrictions on the variable.).
- ☐ **CF3.04** **CR2006** – determine if two given algebraic expressions are equivalent (i.e., by simplifying; by substituting values) [Sample problem: Determine if the expressions $2x^2$ - 4x - 6 / x = 1 and $8x^2$ - 2x(4x - 1) - 6 are equivalent.].

Gr.11 Functions---Exponential Functions MCR 3U

Representing Exponential Functions

- ☐ **EF1.02** **CR2006** – determine, through investigation using a variety of tools (e.g., calculator, paper and pencil, graphing technology) and strategies (e.g., patterning;finding values from a graph;interpreting the exponent laws), the value of a power with a rational exponent (i.e., x, where x >0 and m and n are integers) (Sample problem:The exponent laws suggest that $4^{1/2}$ x $4^{1/2}$ = 4^1 .What value would you assign to $4^{1/2}$? What value would you assign to $27^{1/3}$? Explain your reasoning. Extend your reasoning to make a generalization about the meaning of $x^{1/n}$,where x > 0 and n is a natural number.);
- ☐ **EF1.04** **CR2006** – determine, through investigation,and describe key properties relating to domain and range, intercepts, increasing/decreasing intervals, and asymptotes (e.g., the domainis the set of real numbers; the range is the set of positive real numbers; the function either increases or decreases throughout its domain) for exponential functions represented in a variety of ways [e.g., tables of values, mapping diagrams, graphs,equations of the form f(x) = a^x(a > 0, a ≠ 1), function machines] [Sample problem:Graph f(x) = 2^x, g(x) = 3^x, and h(x) = 0.5^x on the same set of axes. Make comparisons between the graphs,and explain the relationship between the y-intercepts.].

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Connecting Graphs and Equations of Exponential Functions

- ☐ **EF2.01 CR2006** – distinguish exponential functions fromlinear and quadratic functions by making comparisons in a variety of ways (e.g.,comparing rates of change using finite differences in tables of values; identifying a constant ratio in a table of values; inspecting graphs; comparing equations) [Sample problem:Explain in a variety of ways how you can distinguish the exponential function $f(x) = 2^x$ from the quadratic function $f(x) = x^2$ and the linear function $f(x) = 2^x$];
- ☐ **EF2.02 CR2006** – determine, through investigation using technology, and describe the roles of the parameters a, k, d,and c in functions of the form y = af(k(x - d)) + c in terms of transformations on the graph of $f(x) = a^x(a > 0, a \neq 1)$ (i.e., translations; reflections in the axes; vertical and horizontal stretches and compressions) [Sample problem: Investigate the graph f(x) =3x - d- 5 for various values of d, using technology, and describe the effects of changing d in terms of a transformation.];
- ☐ **EF2.03 CR2006** – sketch graphs of y = af(k(x - d)) + c by applying one or more transformations to the graph of f(x) = ax, a >0, a ≠1,and state the domain and range of the transformed functions [Sample problem:Transform the graph of $f(x) = 3^x$ to sketch $g(x) = 3^{-(x+1)} - 2$, and state the domainand range of each function.];
- ☐ **EF2.05 CR2006** – represent an exponential function with an equation, given its graph or its properties (Sample problem: Write two equations to represent the same exponential function with a y-intercept of 5 and an asymptoteat y = 3. Investigate whether other exponential functions have the same properties. Use transformations to explain your observations.).

Solving Problems Involving Exponential Functions

- ☐ **EF3.01 CR2006** – collect data that can be modelled as an exponential function, through investigation with and without technology, from primary sources, using a variety of tools (e.g., concrete materials such as number cubes, coins; measurement tools such as electronic probes), or from secondary sources (e.g., websites such as Statistics Canada, E-STAT), and graph the data (Sample problem: Collect data and graph the cooling curve representing the relationship between temperature and time for hot water cooling in a porcelain mug. Predict the shape of the cooling curve when hot water cools in an insulated mug. Test your prediction.);
- ☐ **EF3.02 CR2006** – identify exponential functions, including those that arise from real-world applications involving growth and decay (e.g., radioactive decay, population growth, cooling rates, pressure in a leaking tire), given various representations (i.e., tables of values, graphs, equations), and explain any restrictions that the context places on the domain and range (e.g., ambient temperature limits the range for a cooling curve) (Sample problem: Using data from Statistics Canada, investigate to determine if there was a period of time over which the increase in Canada?s national debt could be modelled using an exponential function.);
- ☐ **EF3.03 CR2006** – solve problems using given graphs or equations of exponential functions arising from a variety of real-world applications (e.g., radioactive decay, population growth, height of a bouncing ball, compound interest) by interpreting the graphs or by substituting values for the exponent into the equations [Sample problem: The temperature of a cooling liquid over time can be modelled by the exponential function $T(x) = 60(1/2)^{x/30} + 20$, where T(x) is the temperature, in degrees Celsius, and x is the elapsed time, in minutes. Graph the function and determine how long it takes for the temperature to reach 28°C.].

Gr.11 Functions---Discrete Functions MCR 3U

Representing Sequences

- ☐ **DF1.04 CR2006** – represent a sequence algebraically using arecursion formula,function notation,or theformula for the nth term [e.g.,represent 2, 4, 8, 16, 32, 64,... as $t_1 = 2$; $t_n = 2t_{n-1}$, as $f(n) = 2^n$,or as $t_n = 2^n$, or represent 1/2, 2/3, 3/4, 4/5, 5/6, 6/7, ... as $t_1 = 1/2$; $t_n = t_{n-1} + 1/(n(n + 1))$, as f(n) = n/(n + 1), or as $t_n = n/n+1$, where n is a natural number], and describe the information that can be obtained by inspecting each representation (e.g., function notation or the formula for the nth term may show the type of function; a recursion formula shows the relationship between terms) (Sample Problem: Represent the sequence 0, 3, 8,15, 24, 35,... using a recursion formula,function notation,and the formula for the nth term.Explain why this sequence can be described as a discretequadratic function. Explore how to identify a sequence as a discrete quadratic function by inspecting the recursion formula.);

Investigating Arithmetic and Geometric Sequences and Series

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- ☐ **DF2.03** **CR2006** – determine the formula for the sum of an arithmetic or geometric series, through investigation using a variety of tools (e.g., linking cubes, algebra tiles, diagrams, calculators) and strategies (e.g., patterning; connecting the steps in a numerical example to the steps in the algebraic development), and apply the formula to calculate the sum of a given number of consecutive terms (Sample problem: Given the array built with grey and white connecting cubes, investigate how different ways of determining the total number of grey cubes can be used to evaluate the sum of the arithmetic series 1 + 2 + 3 + 4 + 5. Extend the series, use patterning to make generalizations for finding the sum, and test the generalizations for other arithmetic series.);(omitted graphic on page 38)

Solving Problems Involving Financial Applications

- ☐ **DF3.01** **CR2006** – make and describe connections between simple interest, arithmetic sequences, and linear growth, through investigation with technology (e.g., use a spreadsheet or graphing calculator to make simple interest calculations, determine first differences in the amounts over time, and graph amount versus time) [Sample problem: Describe an investment that could be represented by the function f (x) = 500(1.05x).];
- ☐ **DF3.02** **CR2006** – make and describe connections between compound interest, geometric sequences, and exponential growth, through investigation with technology (e.g., use a spreadsheet to make compound interest calculations, determine finite differences in the amounts over time, and graph amount versus time) [Sample problem: Describe an investment that could be represented by the function f (x) = $500(1.05)^x$.];
- ☐ **DF3.03** **CR2006** – solve problems, using a scientific calculator, that involve the calculation of the amount, A (also referred to as future value, FV), the principal, P (also referred to as present value, PV), or the interest rate per compounding period, i, using the compound interest formula in the form $A = P(1 + i)^n$ [or $FV = PV(1 + i)^n$] (Sample problem: Two investments are available, one at 6% compounded annually and the other at 6% compounded monthly. Investigate graphically the growth of each investment, and determine the interest earned from depositing $1000 in each investment for 10 years.);
- ☐ **DF3.06** **CR2006** – determine, through investigation using technology (e.g., the TVM Solver in a graphing calculator; online tools), the effects of changing the conditions (i.e., the payments, the frequency of the payments, the interest rate, the compounding period) of ordinary annuities in situations where the compounding period and the payment period are the same (e.g., long-term savings plans, loans) (Sample problem: Compare the amounts at age 65 that would result from making an annual deposit of $1000 starting at age 20, or from making an annual deposit of $3000 starting at age 50, to an RRSP that earns 6% interest per annum, compounded annually. What is the total of the deposits in each situation?);

Gr.11 Functions---Trigonometric Functions MCR 3U

Determining and Applying Trigonometric Ratios

- ☐ **TF1.05** **CR2006** – prove simple trigonometric identities, using the Pythagorean identity $\sin^2 x + \cos^2 x = 1$; sinx the quotient identity tanx = sinx / cosx ; and the reciprocal identities secx = 1 / cosx, cscx = 1 /sinx , and cotx = 1/ tanx (Sample problem: Prove that $1- \cos^2 x$ = sinxcosxtanx.);
- ☐ **TF1.07** **CR2006** – pose and solve problems involving right triangles and oblique triangles in three-dimensional settings, using the primary trigonometric ratios, the cosine law, and the sine law (Sample problem: Explain how a surveyor could find the height of a vertical cliff that is on the other side of a raging river, using a measuring tape, a theodolite, and some trigonometry. Create data that the surveyor might measure, and use the data to calculate the height of the cliff.).

Connecting Graphs and Equations of Sinusoidal Functions

- ☐ **TF2.05** **CR2006** – determine, through investigation using technology, and describe the roles of the parameters a, k, d,and c in functions of the form y = af(k(x - d)) + c in terms of transformations on the graphs of f(x) = sinx and f(x) = cosx with angles expressed in degrees (i.e., translations; reflections in the axes; vertical and horizontal stretches and compressions) [Sample problem: Investigate the graph f(x) = 2sin(x -d) + 10 for various values of d, using technology, and describe the effects of changing d in terms of a transformation.];
- ☐ **TF2.07** **CR2006** – sketch graphs of y = af(k(x - d)) + c by applying one or more transformations to the graphs of f(x) = sinx and f(x) = cosx, and state the domain and range of the transformed functions [Sample problem: Transform the graph of f(x) = cos x to sketch g(x) = 3cos2x - 1, and state the domain and range of each function.];

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- ☐ **TF2.08** **CR2006** – represent a sinusoidal function with an equation, given its graph or its properties [Sample problem: A sinusoidal function has an amplitude of 2 units, a period of 180°, and a maximum at (0, 3). Represent the function with an equation in two different ways.].

Solving Problems Involving Sinusoidal Functions

- ☐ **TF3.01** **CR2006** – collect data that can be modelled as a sinusoidal function (e.g., voltage in an AC circuit, sound waves), through investigation with and without technology, from primary sources, using a variety of tools (e.g., concrete materials; measurement tools such as motion sensors), or from secondary sources (e.g., websites such as Statistics Canada, E-STAT), and graph the data (Sample problem: Measure and record distance-time data for a swinging pendulum, using a motion sensor or other measurement tools, and graph the data.);
- ☐ **TF3.02** **CR2006** – identify sinusoidal functions, including those that arise from real-world applications involving periodic phenomena, given various representations (i.e., tables of values, graphs, equations), and explain any restrictions that the context places on the domain and range (Sample problem: Using data from Statistics Canada, investigate to determine if there was a period of time over which changes in the population of Canadians aged 20-24 could be modelled using a sinusoidal function.);
- ☐ **TF3.03** **CR2006** – determine, through investigation, how sinusoidal functions can be used to model periodic phenomena that do not involve angles [Sample problem: Investigate,using graphing technology in degree mode, and explain how the function h(t) = 5sin(30(t + 3)) approximately models the relationship between the height and the time of day for a tide with an amplitude of 5 m, if high tide is at midnight.];
- ☐ **TF3.04** **CR2006** – predict the effects on a mathematical model (i.e., graph, equation) of an application involving sinusoidal functions when the conditions in the application are varied (e.g., varying the conditions, such as speed and direction, when walking in a circle in front of a motion sensor) (Sample problem: The relationship between the height above the ground of a person riding a Ferris wheel and time can be modelled using a sinusoidal function. Describe the effect on this function if the platform from which the person enters the ride is raised by 1 m and if the Ferris wheel turns twice as fast.);
- ☐ **TF3.05** **CR2006** – pose and solve problems based on applications involving a sinusoidal function by using a given graph or a graph generated with technology from its equation [Sample problem: The height above the ground of a rider on a Ferris wheel can be modelled by the sine function h(t) = 25sin3(t - 30) + 27, where h(t) is the height, in metres, and t is the time, in seconds. Graph the function, using graphing technology in degree mode, and determine the maximum and minimum heights of the rider, the height after 30 s, and the time required to complete one revolution.].

Gr.12 Mathematics for College Technology---A. EXPONENTIAL FUNCTIONS MCT 4C

1. Solving Exponential Equations Graphically

- ☐ **EF1.02** **CR2007** 1.2 solve simple exponential equations numerically and graphically, with technology (e.g., use systematic trial with a scientific calculator to determine the solution to the equation $1.05^x = 1{,}276$), and recognize that the solutions may not be exact Sample problem: Use the graph of $y = 3^x$ to solve the equation $3^x = 5$.
- ☐ **EF1.03** **CR2007** 1.3 determine, through investigation using graphing technology, the point of intersection of the graphs of two exponential functions (e.g., $y = 4^{-x}$ and $y = 8^{x+3}$), recognize the x-coordinate of this point to be the solution to the corresponding exponential equation (e.g., $4^{-x} = 8^{x+3}$), and solve exponential equations graphically (e.g., solve $2^{x+2} = 2^x + 12$ by using the intersection of the graphs of $y = 2^{x+2}$ and $y = 2^x + 12$) Sample problem: Solve $0.5^x = 3^{x+3}$ graphically.
- ☐ **EF1.04** **CR2007** 1.4 pose problems based on real-world applications (e.g., compound interest, population growth) that can be modelled with exponential equations, and solve these and other such problems by using a given graph or a graph generated with technology from a table of values or from its equation Sample problem: A tire with a slow puncture loses pressure at the rate of 4%/min. If the tire's pressure is 300 kPa to begin with, what is its pressure after 1 min? After 2 min? After 10 min? Use graphing technology to determine when the tire's pressure will be 200 kPa.

2. Solving Exponential Equations Algebraically

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- ☐ **EF2.01** **CR2007** 2.1 simplify algebraic expressions containing integer and rational exponents using the laws of exponents (e.g., $x^3/x^{1/2}$, $\sqrt{x^6y^{12}}$) Sample problem: Simplify $a^3b^2c^3/\sqrt{a^2b^4}$ and then evaluate for a = 4, b = 9, and c =–3. Verify your answer by evaluating the expression without simplifying first. Which method for evaluating the expression do you prefer? Explain.
- ☐ **EF2.02** **CR2007** 2.2 solve exponential equations in one variable by determining a common base (e.g., $2^x = 32$, $4^{5x-1} = 2^{2(x+11)}$, $3^{5x+8} = 27^x$) Sample problem: Solve $3^{5x+8} = 27^x$ by determining a common base, verify by substitution, and investigate connections to the intersection of $y = 3^{5x+8}$ and $y = 27^x$ using graphing technology.
- ☐ **EF2.03** **CR2007** 2.3 recognize the logarithm of a number to a given base as the exponent to which the base must be raised to get the number, recognize the operation of finding the logarithm to be the inverse operation (i.e., the undoing or reversing) of exponentiation, and evaluate simple logarithmic expressions Sample problem: Why is it possible to determine $\log_{10}(100)$ but not $\log_{10}(0)$ or $\log_{10}(-100)$? Explain your reasoning.
- ☐ **EF2.06** **CR2007** 2.6 pose problems based on real-world applications that can be modelled with given exponential equations, and solve these and other such problems algebraically by rewriting them in logarithmic form Sample problem: When a potato whose temperature is 20° C is placed in an oven maintained at 200°C, the relationship between the core temperature of the potato T, in degrees Celsius, and the cooking time t, in minutes, is modelled by the equation 200 – T = 180(0.96)t. Use logarithms to determine the time when the potato's core temperature reaches 160°C.

Gr.12 Mathematics for College Technology---B. POLYNOMIAL FUNCTIONS MCT 4C

1. Investigating Graphs of Polynomial Functions

- ☐ **PF1.02** **CR2007** 1.2 compare, through investigation using graphing technology, the graphical and algebraic representations of polynomial (i.e., linear, quadratic, cubic, quartic) functions (e.g., investigate the effect of the degree of a polynomial function on the shape of its graph and the maximum number of x-intercepts; investigate the effect of varying the sign of the leading coefficient on the end behaviour of the function for very large positive or negative x-values) Sample problem: Investigate the maximum number of x-intercepts for linear, quadratic, cubic, and quartic functions using graphing technology.
- ☐ **PF1.03** **CR2007** 1.3 describe key features of the graphs of polynomial functions (e.g., the domain and range, the shape of the graphs, the end behaviour of the functions for very large positive or negative x-values) Sample problem: Describe and compare the key features of the graphs of the functions f(x) = x, $f(x) = x^2$, $f(x) = x^3$, and $f(x) = x^4$.
- ☐ **PF1.05** **CR2007** 1.5 substitute into and evaluate polynomial functions expressed in function notation, including functions arising from real-world applications Sample problem: A box with no top is being made out of a 20-cm by 30-cm piece of cardboard by cutting equal squares of side length x from the corners and folding up the sides. The volume of the box is V = x(20 – 2x)(30 – 2x). Determine the volume if the side length of each square is 6 cm. Use the graph of the polynomial function V(x)to determine the size of square that should be cut from the corners if the required volume of the box is 1000 cm^3.
- ☐ **PF1.07** **CR2007** 1.7 recognize, using graphs, the limitations of modelling a real-world relationship using a polynomial function, and identify and explain any restrictions on the domain and range (e.g., restrictions on the height and time for a polynomial function that models the relationship between height above the ground and time for a falling object) Sample problem: The forces acting on a horizontal support beam in a house cause it to sag by d centimetres, x metres from one end of the beam. The relationship between d and x can be represented by the polynomial function $d(x) = (1/1850)x(1000 - 20x^2 + x^3)$. Graph the function, using technology, and determine the domain over which the function models the relationship between d and x. Determine the length of the beam using the graph, and explain your reasoning.

2. Connecting Graphs and Equations of Polynomial Functions

- ☐ **PF2.01** **CR2007** 2.1 factor polynomial expressions in one variable, of degree no higher than four, by selecting and applying strategies (i.e., common factoring, difference of squares, trinomial factoring) Sample problem: Factor: $x^4 - 16$; $x^3 - 2x^2 - 8x$.

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within: **Mathematics**

- ☐ **PF2.02** **CR2007** 2.2 make connections, through investigation using graphing technology (e.g., dynamic geometry software), between a polynomial function given in factored form [e.g., $f(x) = x(x – 1)(x + 1)$] and the x-intercepts of its graph, and sketch the graph of a polynomial function given in factored form using its key features (e.g., by determining intercepts and end behaviour; by locating positive and negative regions using test values between and on either side of the x-intercepts) Sample problem: Sketch the graphs of $f(x) = –(x – 1)(x + 2)(x – 4)$ and $g(x) = –(x – 1)(x + 2)(x + 2)$ and compare their shapes and the number of x-intercepts.

- ☐ **PF2.03** **CR2007** 2.3 determine, through investigation using technology (e.g., graphing calculator, computer algebra systems), and describe the connection between the real roots of a polynomial equation and the x-intercepts of the graph of the corresponding polynomial function [e.g., the real roots of the equation $x^4 – 13x^2 + 36 = 0$ are the x-intercepts of the graph of $f(x) = x^4 – 13x^2 + 36$] Sample problem: Describe the relationship between the x-intercepts of the graphs of linear and quadratic functions and the real roots of the corresponding equations. Investigate, using technology, whether this relationship exists for polynomial functions of higher degree.

3. Solving Problems Involving Polynomial Equations

- ☐ **PF3.01** **CR2007** 3.1 solve polynomial equations in one variable, of degree no higher than four (e.g., $x^2 – 4x = 0$, $x^4 – 16 = 0$, $3x^2 + 5x + 2 = 0$), by selecting and applying strategies (i.e., common factoring; difference of squares; trinomial factoring), and verify solutions using technology (e.g., using computer algebra systems to determine the roots of the equation; using graphing technology to determine the x-intercepts of the corresponding polynomial function) Sample problem: Solve $x^3 – 2x^2 – 8x = 0$.
- ☐ **PF3.03** **CR2007** 3.3 identify and explain the roles of constants and variables in a given formula (e.g., a constant can refer to a known initial value or a known fixed rate; a variable changes with varying conditions) Sample problem: The formula $P = P_0+ kh$ is used to determine the pressure, P kilopascals, at a depth of h metres under water, where k kilopascals per metre is the rate of change of the pressure as the depth increases, and P_0 kilopascals is the pressure at the surface. Identify and describe the roles of P, P_0, k, and h in this relationship, and explain your reasoning.
- ☐ **PF3.04** **CR2007** 3.4 expand and simplify polynomial expressions involving more than one variable [e.g., simplify $–2xy(3x^2y^3 – 5x^3y^2)$], including expressions arising from real-world applications Sample problem: Expand and simplify the expression $\pi(R + r)(R – r)$ to explain why it represents the area of a ring. Draw a diagram of the ring and identify R and r.
- ☐ **PF3.06** **CR2007** 3.6 determine the value of a variable of degree no higher than three, using a formula drawn from an application, by first substituting known values and then solving for the variable, and by first isolating the variable and then substituting known values Sample problem: The formula $s = ut + 1/2\ at^2$ relates the distance, s, travelled by an object to its initial velocity, u, acceleration, a, and the elapsed time, t. Determine the acceleration of a dragster that travels 500 m from rest in 15 s, by first isolating a, and then by first substituting known values. Compare and evaluate the two methods.
- ☐ **PF3.07** **CR2007** 3.7 make connections between formulas and linear, quadratic, and exponential functions [e.g., recognize that the compound interest formula, $A = P(1 + i)^n$, is an example of an exponential function A(n) when P and i are constant, and of a linear function A(P) when i and n are constant], using a variety of tools and strategies (e.g., comparing the graphs generated with technology when different variables in a formula are set as constants) Sample problem: Which variable(s) in the formula $V = \pi r^2h$ would you need to set as a constant to generate a linear equation? A quadratic equation?

Gr.12 Mathematics for College Technology---C. TRIGONOMETRIC FUNCTIONS MCT 4C

1. Applying Trigonometric Ratios

- ☐ **TF1.03** **CR2007** 1.3 determine the measures of two angles from 0° to 360° for which the value of a given trigonometric ratio is the same (e.g., determine one angle using a calculator and infer the other angle) Sample problem: Determine the approximate measures of the angles from 0° to 360° for which the sine is 0.3423.

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- ☐ **TF1.04** **CR2007** 1.4 solve multi-step problems in two and three dimensions, including those that arise from real-world applications (e.g., surveying, navigation), by determining the measures of the sides and angles of right triangles using the primary trigonometric ratios Sample problem: Explain how you could find the height of an inaccessible antenna on top of a tall building, using a measuring tape, a clinometer, and trigonometry. What would you measure, and how would you use the data to calculate the height of the antenna?

- ☐ **TF1.05** **CR2007** 1.5 solve problems involving oblique triangles, including those that arise from real-world applications, using the sine law (including the ambiguous case) and the cosine law Sample problem: The following diagram represents a mechanism in which point B is fixed, point C is a pivot, and a slider A can move horizontally as angle B changes. The minimum value of angle B is 35°. How far is it from the extreme left position to the extreme right position of slider A? (omitted the graph on page 130)

2. Connecting Graphs and Equations of Sinusoidal Functions

- ☐ **TF2.02** **CR2007** 2.2 sketch the graphs of f(x) = sin x and f(x) = cos x for angle measures expressed in degrees, and determine and describe their key properties (i.e., cycle, domain, range, intercepts, amplitude, period, maximum and minimum values, increasing/decreasing intervals) Sample problem: Describe and compare the key properties of the graphs of f(x) = sin x and f(x) = cos x. Make some connections between the key properties of the graphs and your understanding of the sine and cosine ratios.
- ☐ **TF2.03** **CR2007** 2.3 determine, through investigation using technology, the roles of the parameters d and c in functions of the form y = sin(x – d) + c and y = cos(x – d) + c, and describe these roles in terms of transformations on the graphs of f(x) = sin x and f(x) = cos x with angles expressed in degrees (i.e., vertical and horizontal translations) Sample problem: Investigate the graph f(x) = 2sin(x – d) + 10 for various values of d, using technology, and describe the effects of changing d in terms of a transformation.
- ☐ **TF2.04** **CR2007** 2.4 determine, through investigation using technology, the roles of the parameters a and k in functions of the form y = a sin kx and y = a cos kx, and describe these roles in terms of transformations on the graphs of f(x) = sin x and f(x) = cos x with angles expressed in degrees (i.e., reflections in the axes; vertical and horizontal stretches and compressions to and from the x- and y-axes) Sample problem: Investigate the graph f(x) = 2sin kx for various values of k, using technology, and describe the effects of changing k in terms of transformations.
- ☐ **TF2.05** **CR2007** 2.5 determine the amplitude, period, and phase shift of sinusoidal functions whose equations are given in the form f(x) = a sin(k(x – d)) + c or f(x) = a cos(k(x – d)) + c, and sketch graphs of y = a sin(k(x – d)) + c and y = a cos(k(x – d)) + c by applying transformations to the graphs of f(x) = sin x and f(x) = cos x Sample problem: Transform the graph of f(x) = cos x to sketch g(x) = 3cos(x + 90°) and h(x) = cos(2x) – 1, and state the amplitude, period, and phase shift of each function.
- ☐ **TF2.06** **CR2007** 2.6 represent a sinusoidal function with an equation, given its graph or its properties Sample problem: A sinusoidal function has an amplitude of 2 units, a period of 180°, and a maximum at (0,3). Represent the function with an equation in two different ways, using first the sine function and then the cosine function.

3. Solving Problems Involving Sinusoidal Functions

- ☐ **TF3.01** **CR2007** 3.1 collect data that can be modelled as a sinusoidal function (e.g., voltage in an AC circuit, pressure in sound waves, the height of a tack on a bicycle wheel that is rotating at a fixed speed), through investigation with and without technology, from primary sources, using a variety of tools (e.g., concrete materials, measurement tools such as motion sensors), or from secondary sources (e.g., websites such as Statistics Canada, E-STAT), and graph the data Sample problem: Measure and record distance-time data for a swinging pendulum, using a motion sensor or other measurement tools, and graph the data. Describe how the graph would change if you moved the pendulum further away from the motion sensor. What would you do to generate a graph with a smaller amplitude?
- ☐ **TF3.02** **CR2007** 3.2 identify periodic and sinusoidal functions, including those that arise from real-world applications involving periodic phenomena, given various representations (i.e., tables of values, graphs, equations), and explain any restrictions that the context places on the domain and range Sample problem: The depth, w metres, of water in a lake can be modelled by the function w = 5sin(31.5n + 63) + 12, where n is the number of months since January 1, 1995. Identify and explain the restrictions on the domain and range of this function.

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- ☐ **TF3.03** **CR2007** 3.3 pose problems based on applications involving a sinusoidal function, and solve these and other such problems by using a given graph or a graph generated with technology, in degree mode, from a table of values or from its equation Sample problem: The height above the ground of a rider on a Ferris wheel can be modelled by the sinusoidal function h(t) = 25cos(3(t – 60)) + 27, where h(t) is the height in metres and t is the time in seconds. Graph the function, using graphing technology in degree mode, and determine the maximum and minimum heights of the rider, the height after 30 s, and the time required to complete one revolution.

Gr.12 Mathematics for College Technology---D. APPLICATIONS OF GEOMETRY MCT 4C

1. Modelling With Vectors

- ☐ **AG1.01** **CR2007** 1.1 recognize a vector as a quantity with both magnitude and direction, and identify, gather, and interpret information about real-world applications of vectors (e.g., displacement; forces involved in structural design; simple animation of computer graphics; velocity determined using GPS) Sample problem: Position is represented using vectors. Explain why knowing that someone is 69 km from Lindsay, Ontario, is not sufficient to identify their exact position.
- ☐ **AG1.03** **CR2007** 1.3 resolve a vector represented as a directed line segment into its vertical and horizontal components Sample problem: A cable exerts a force of 558 N at an angle of 37.2° with the horizontal. Resolve this force into its vertical and horizontal components. (omitted graph from page 133)
- ☐ **AG1.06** **CR2007** 1.6 solve problems involving the addition and subtraction of vectors, including problems arising from real-world applications (e.g., surveying, statics, orienteering) Sample problem: Two people pull on ropes to haul a truck out of some mud. The first person pulls directly forward with a force of 400 N, while the other person pulls with a force of 600 N at a 50° angle to the first person along the horizontal plane. What is the resultant force used on the truck?

2. Solving Problems Involving Geometry

- ☐ **AG2.01** **CR2007** 2.1 gather and interpret information about real-world applications of geometric shapes and figures in a variety of contexts in technology-related fields (e.g., product design, architecture), and explain these applications (e.g., one reason that sewer covers are round is to prevent them from falling into the sewer during removal and replacement) Sample problem: Explain why rectangular prisms are often used for packaging.
- ☐ **AG2.03** **CR2007** 2.3 solve problems involving the areas of rectangles, parallelograms, trapezoids, triangles, and circles, and of related composite shapes, in situations arising from real-world applications Sample problem: Your company supplies circular cover plates for pipes. How many plates with a 1-ft radius can be made from a 4-ft by 8-ft sheet of stainless steel? What percentage of the steel will be available for recycling?
- ☐ **AG2.04** **CR2007** 2.4 solve problems involving the volumes and surface areas of spheres, right prisms, and cylinders, and of related composite figures, in situations arising from real-world applications Sample problem: For the small factory shown in the following diagram, design specifications require that the air be exchanged every 30 min. Would a ventilation system that exchanges air at a rate of 400 ft /min satisfy the specifications? Explain. (omitted graph on page 134)

3. Solving Problems Involving Circle Properties

- ☐ **AG3.02** **CR2007** 3.2 determine the length of an arc and the area of a sector or segment of a circle, and solve related problems Sample problem: A circular lake has a diameter of 4 km. Points A and D are on opposite sides of the lake and lie on a straight line through the centre of the lake, with each point 5 km from the centre. In the route ABCD, AB and CD are tangents to the lake and BC is an arc along the shore of the lake. How long is this route? (omitted graph on page 134)
- ☐ **AG3.03** **CR2007** 3.3 determine, through investigation using a variety of tools (e.g., dynamic geometry software), properties of the circle associated with chords, central angles, inscribed angles, and tangents (e.g., equal chords or equal arcs subtend equal central angles and equal inscribed angles; a radius is perpendicular to a tangent at the point of tangency defined by the radius, and to a chord that the radius bisects) Sample problem: Investigate, using dynamic geometry software, the relationship between the lengths of two tangents drawn to a circle from a point outside the circle.

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☐ **AG3.04** **CR2007** 3.4 solve problems involving properties of circles, including problems arising from real-world applications Sample problem: A cylindrical metal rod with a diameter of 1.2 cm is supported by a wooden block, as shown in the following diagram. Determine the distance from the top of the block to the top of the rod. (omitted graph on page 134)

Gr.12 Calculus and Vectors---A. RATE OF CHANGE MCV 4U

1. Investigating Instantaneous Rate of Change at a Point

☐ **RC1.02** **CR2007** 1.2 describe connections between the average rate of change of a function that is smooth (i.e., continuous with no corners) over an interval and the slope of the corresponding secant, and between the instantaneous rate of change of a smooth function at a point and the slope of the tangent at that point Sample problem: Given the graph of f(x) shown below, explain why the instantaneous rate of change of the function cannot be determined at point P. (graph omitted from page 101)

☐ **RC1.04** **CR2007** 1.4 recognize, through investigation with or without technology, graphical and numerical examples of limits, and explain the reasoning involved (e.g., the value of a function approaching an asymptote, the value of the ratio of successive terms in the Fibonacci sequence) Sample problem: Use appropriate technology to investigate the limiting value of the terms in the sequence $(1 + 1/1)^1$, $(1 + 1/2)^2$, $(1 + 1/3)^3$, $(1 + 1/4)^4$, ..., and the limiting value of the series 4 x 1 – 4 x 1/3 + 4 x 1/5 –4 x 1/7 + 4 x 1/9 – ....

☐ **RC1.05** **CR2007** 1.5 make connections, for a function that is smooth over the interval $a \le x \le a + h$, between the average rate of change of the function over this interval and the value of the expression [f(a + h) – f(a)]/h , and between the instantaneous rate of change of the function at x = a and the value of the limit $\lim_{h\to 0}$ [f(a + h) – f(a)]/h Sample problem: What does the limit $\lim_{h\to 0}$ [f(4 + h) – f(4)]/h = 8 indicate about the graph of the function $f(x) = x^2$? The graph of a general function y = f(x)?

2. Investigating the Concept of the Derivative Function

☐ **RC2.01** **CR2007** 2.1 determine numerically and graphically the intervals over which the instantaneous rate of change is positive, negative, or zero for a function that is smooth over these intervals (e.g., by using graphing technology to examine the table of values and the slopes of tangents for a function whose equation is given; by examining a given graph), and describe the behaviour of the instantaneous rate of change at and between local maxima and minima Sample problem: Given a smooth function for which the slope of the tangent is always positive, explain how you know that the function is increasing. Give an example of such a function.

☐ **RC2.02** **CR2007** 2.2 generate, through investigation using technology, a table of values showing the instantaneous rate of change of a polynomial function, f(x), for various values of x (e.g., construct a tangent to the function, measure its slope, and create a slider or animation to move the point of tangency), graph the ordered pairs, recognize that the graph represents a function called the derivative, f'(x) or dy/dx, and make connections between the graphs of f(x) and f'(x) or y and dy/dx [e.g., when f(x) is linear, f'(x) is constant; when f(x) is quadratic, f'(x) is linear; when f(x) is cubic, f'(x) is quadratic] Sample problem: Investigate, using patterning strategies and graphing technology, relationships between the equation of a polynomial function of degree no higher than 3 and the equation of its derivative.

☐ **RC2.05** **CR2007** 2.5 determine, through investigation using technology, the graph of the derivative f'(x)or dy/dx of a given exponential function [i.e., $f(x) = a^x$ ($a > 0$, $a \neq 1$)] [e.g., by generating a table of values showing the instantaneous rate of change of the function for various values of x and graphing the ordered pairs; by using dynamic geometry software to verify that when $f(x) = a^x$, f'(x) = kf(x)], and make connections between the graphs of f(x) and f'(x) or y and dy/dx [e.g., f(x) and f'(x) are both exponential; the ratio f'(x)/f(x) is constant, or f'(x) = kf(x); f'(x) is a vertical stretch from the x-axis of f(x)] Sample problem: Graph, with technology, $f(x) = a^x$ ($a > 0$, $a \neq 1$) and f'(x) on the same set of axes for various values of a (e.g., 1.7, 2.0, 2.3, 3.0, 3.5). For each value of a, investigate the ratio f'(x)/f(x) for various values of x, and explain how you can use this ratio to determine the slopes of tangents to f(x).

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☐ **RC2.06 CR2007**
2.6 determine, through investigation using technology, the exponential function $f(x) = a^x (a > 0, a \neq 1)$ for which $f'(x) = f(x)$ (e.g., by using graphing technology to create a slider that varies the value of a in order to determine the exponential function whose graph is the same as the graph of its derivative), identify the number e to be the value of a for which $f'(x) = f(x)$ [i.e., given $f(x) = e^x$, $f (x) = e^x$], and recognize that for the exponential function $f(x) = e^x$ the slope of the tangent at any point on the function is equal to the value of the function at that point Sample problem: Use graphing technology to determine an approximate value of e by graphing $f(x) = a^x$ $(a > 0, a \neq 1)$ for various values of a, comparing the slope of the tangent at a point with the value of the function at that point, and identifying the value of a for which they are equal.

☐ **RC2.08 CR2007**
2.8 verify, using technology (e.g., calculator, graphing technology), that the derivative of the exponential function $f(x) = a^x$ is $f'(x) = a^x \ln a$ for various values of a [e.g., verifying numerically for $f(x) = 2^x$ that $f'(x) = 2^x \ln 2$ by using a calculator to show that $\lim_{h\to 0} (2^h - 1)/h$ is ln 2 or by graphing $f(x) = 2^x$, determining the value of the slope and the value of the function for specific x-values, and comparing the ratio $f'(x)/f(x)$ with ln 2] Sample problem: Given $f(x) = e^x$, verify numerically with technology using $\lim_{h\to 0} (e^{x+h} - e^x)/h$ that $f'(x) = f(x)\ln e$.

3. Investigating the Properties of Derivatives

☐ **RC3.02 CR2007**
3.2 verify the constant, constant multiple, sum, and difference rules graphically and numerically [e.g., by using the function $g(x) = kf(x)$ and comparing the graphs of $g'(x)$ and $kf'(x)$; by using a table of values to verify that $f'(x) + g'(x) = (f + g)'(x)$, given $f(x) = x$ and $g(x) = 3x$], and read and interpret proofs involving $\lim_{h\to 0} [f(x + h) - f(x)]/h$ of the constant, constant multiple, sum, and difference rules (student reproduction of the development of the general case is not required) Sample problem: The amounts of water flowing into two barrels are represented by the functions f(t) and g(t). Explain what $f'(t)$, $g'(t)$, $f'(t) + g'(t)$, and $(f + g)'(t)$ represent. Explain how you can use this context to verify the sum rule, $f'(t) + g'(t) = (f + g)'(t)$.

☐ **RC3.03 CR2007**
3.3 determine algebraically the derivatives of polynomial functions, and use these derivatives to determine the instantaneous rate of change at a point and to determine point(s) at which a given rate of change occurs Sample problem: Determine algebraically the derivative of $f(x) = 2x^3 + 3x^2$ and the point(s) at which the slope of the tangent is 36.

☐ **RC3.04 CR2007**
3.4 verify that the power rule applies to functions of the form $f(x) = x^n$, where n is a rational number [e.g., by comparing values of the slopes of tangents to the function $f(x) = x^{1/2}$ with values of the derivative function determined using the power rule], and verify algebraically the chain rule using monomial functions [e.g., by determining the same derivative for $f(x) = [5x^3]^{1/3}$ by using the chain rule and by differentiating the simplified form, $f(x) = 5x^{1/3}$] and the product rule using polynomial functions [e.g., by determining the same derivative for $f(x) = (3x + 2)(2x^2 - 1)$ by using the product rule and by differentiating the expanded form $f(x) = 6x^3 + 4x^2 - 3x - 2$] Sample problem: Verify the chain rule by using the product rule to look for patterns in the derivatives of $f(x) = x^2 + 1$, $f(x) = [x^2 + 1]^2$, $f(x) = [x^2 + 1]^3$, and $f(x) = [x^2 + 1]^4$].

Gr.12 Calculus and Vectors---B. DERIVATIVES AND THEIR APPLICATIONS MCV 4U

1. Connecting Graphs and Equations of Functions and Their Derivatives

☐ **DA1.01 CR2007**
1.1 sketch the graph of a derivative function, given the graph of a function that is continuous over an interval, and recognize points of inflection of the given function (i.e., points at which the concavity changes) Sample problem: Investigate the effect on the graph of the derivative of applying vertical and horizontal translations to the graph of a given function.

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☐ **DA1.03 CR2007** 1.3 determine algebraically the equation of the second derivative f"(x) of a polynomial or simple rational function f(x), and make connections, through investigation using technology, between the key features of the graph of the function (e.g., increasing/decreasing intervals, local maxima and minima, points of inflection, intervals of concavity) and corresponding features of the graphs of its first and second derivatives (e.g., for an increasing interval of the function, the first derivative is positive; for a point of inflection of the function, the slopes of tangents change their behaviour from increasing to decreasing or from decreasing to increasing, the first derivative has a maximum or minimum, and the second derivative is zero)
Sample problem: Investigate, using graphing technology, connections between key properties, such as increasing/decreasing intervals, local maxima and minima, points of inflection, and intervals of concavity, of the functions $f(x) = 4x + 1$, $f(x) = x^2 + 3x – 10$, $f(x) = x^3 + 2x^2 – 3x$, and $f(x) = x^4 + 4x^3 – 3x^2 – 18x$ and the graphs of their first and second derivatives.

☐ **DA1.04 CR2007** 1.4 describe key features of a polynomial function, given information about its first and/or second derivatives (e.g., the graph of a derivative, the sign of a derivative over specific intervals, the x-intercepts of a derivative), sketch two or more possible graphs of the function that are consistent with the given information, and explain why an infinite number of graphs is possible Sample problem: The following is the graph of the function g(x). (graph omitted from page 106) If g(x) is the derivative of f(x), and f(0) = 0, sketch the graph of f(x). If you are now given the function equation $g(x) = (x – 1)(x – 3)$, determine the equation of f(x) and describe some features of the equation of f(x). How would f(x) change graphically and algebraically if f(0) = 2? "

2. Solving Problems Using Mathematical Models and Derivatives

☐ **DA2.01 CR2007** 2.1 make connections between the concept of motion (i.e., displacement, velocity, acceleration) and the concept of the derivative in a variety of ways (e.g., verbally, numerically, graphically, algebraically) Sample problem: Generate a displacement–time graph by walking in front of a motion sensor connected to a graphing calculator. Use your knowledge of derivatives to sketch the velocity–time and acceleration–time graphs. Verify the sketches by displaying the graphs on the graphing calculator.

☐ **DA2.02 CR2007** 2.2 make connections between the graphical or algebraic representations of derivatives and real-world applications (e.g., population and rates of population change, prices and inflation rates, volume and rates of flow, height and growth rates) Sample problem: Given a graph of prices over time, identify the periods of inflation and deflation, and the time at which the maximum rate of inflation occurred. Explain how derivatives helped solve the problem.

☐ **DA2.03 CR2007** 2.3 solve problems, using the derivative, that involve instantaneous rates of change, including problems arising from real-world applications (e.g., population growth, radioactive decay, temperature changes, hours of day-light, heights of tides), given the equation of a function* Sample problem: The size of a population of butterflies is given by the function $P(t) = 6000/[1 + 49(0.6)^t]$ where t is the time in days. Determine the rate of growth in the population after 5 days using the derivative, and verify graphically using technology. *The emphasis of this expectation is on the application of the derivative rules and not on the simplification of resulting complex algebraic expressions.

☐ **DA2.04 CR2007** 2.4 solve optimization problems involving polynomial, simple rational, and exponential functions drawn from a variety of applications, including those arising from real-world situations Sample problem: The number of bus riders from the suburbs to downtown per day is represented by $1200(1.15)^{-x}$, where x is the fare in dollars. What fare will maximize the total revenue?

☐ **DA2.05 CR2007** 2.5 solve problems arising from real-world applications by applying a mathematical model and the concepts and procedures associated with the derivative to determine mathematical results, and interpret and communicate the results Sample problem: A bird is foraging for berries. If it stays too long in any one patch it will be spending valuable foraging time looking for the hidden berries, but when it leaves it will have to spend time finding another patch. A model for the net amount of food energy in joules the bird gets if it spends t minutes in a patch is $E = 3000t/(t + 4)$. Suppose the bird takes 2 min on average to find each new patch, and spends negligible energy doing so. How long should the bird spend in a patch to maximize its average rate of energy gain over the time spent flying to a patch and foraging in it? Use and compare numeric, graphical, and algebraic strategies to solve this problem.

Gr.12 Calculus and Vectors---C. GEOMETRY AND ALGEBRA OF VECTORS MCV 4U

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1. Representing Vectors Geometrically and Algebraically

- ☐ **GA1.01 CR2007** — 1.1 recognize a vector as a quantity with both magnitude and direction, and identify, gather, and interpret information about real-world applications of vectors (e.g., displacement, forces involved in structural design, simple animation of computer graphics, velocity determined using GPS) Sample problem: Position is represented using vectors. Explain why knowing that someone is 69 km from Lindsay, Ontario, is not sufficient to identify their exact position.
- ☐ **GA1.03 CR2007** — 1.3 determine, using trigonometric relationships [e.g., $x = r\cos\theta$, $y = r\sin\theta$, $\theta = \tan^{-1}(y/x)$ or $\tan^{-1}(y/x) + 180°$, $r = \sqrt{(x^2 + y^2)}$], the Cartesian representation of a vector in two-space given as a directed line segment, or the representation as a directed line segment of a vector in two-space given in Cartesian form [e.g., representing the vector (8, 6) as a directed line segment] x Sample problem: Represent the vector with a magnitude of 8 and a direction of 30° anti-clockwise to the positive x-axis in Cartesian form.

2. Operating With Vectors

- ☐ **GA2.03 CR2007** — 2.3 solve problems involving the addition, subtraction, and scalar multiplication of vectors, including problems arising from real-world applications Sample problem: A plane on a heading of N 27° E has an air speed of 375 km/h. The wind is blowing from the south at 62 km/h. Determine the actual direction of travel of the plane and its ground speed.
- ☐ **GA2.04 CR2007** — 2.4 perform the operation of dot product on two vectors represented as directed line segments (i.e., using vector a • vector b =|vector a||vector b|cosθ) and in Cartesian form (i.e., using vector a • vector b = $a_1b_1 + a_2b_2$ or vector a • vector b = $a_1b_1 + a_2b_2 + a_3b_3$) in two-space and three-space, and describe applications of the dot product (e.g., determining the angle between two vectors; determining the projection of one vector onto another) Sample problem: Describe how the dot product can be used to compare the work done in pulling a wagon over a given distance in a specific direction using a given force for different positions of the handle.
- ☐ **GA2.05 CR2007** — 2.5 determine, through investigation, properties of the dot product (e.g., investigate whether it is commutative, distributive, or associative; investigate the dot product of a vector with itself and the dot product of orthogonal vectors) Sample problem: Investigate geometrically and algebraically the relationship between the dot product of the vectors (1, 0, 1) and (0, 1, – 1) and the dot product of scalar multiples of these vectors. Does this relationship apply to any two vectors? Find a vector that is orthogonal to both the given vectors.
- ☐ **GA2.06 CR2007** — 2.6 perform the operation of cross product on two vectors represented in Cartesian form in three-space [i.e., using vector a x vector b = ($a_2b_3 – a_3b_2$, $a_3b_1 – a_1b_3$, $a_1b_2 – a_2b_1$)], determine the magnitude of the cross product (i.e., using | vector a x vector b|=| vector a|| vector b|sinvector), and describe applications of the cross product (e.g., determining a vector orthogonal to two given vectors; determining the turning effect [or torque] when a force is applied to a wrench at different angles) Sample problem: Explain how you maximize the torque when you use a wrench and how the inclusion of a ratchet in the design of a wrench helps you to maximize the torque.
- ☐ **GA2.07 CR2007** — 2.7 determine, through investigation, properties of the cross product (e.g., investigate whether it is commutative, distributive, or associative; investigate the cross product of collinear vectors) Sample problem: Investigate algebraically the relationship between the cross product of the vectors vector a = (1, 0, 1) and vector b = (0, 1, – 1) and the cross product of scalar multiples of vector a and vector b. Does this relationship apply to any two vectors?
- ☐ **GA2.08 CR2007** — 2.8 solve problems involving dot product and cross product (e.g., determining projections, the area of a parallelogram, the volume of a parallelepiped), including problems arising from real-world applications (e.g., determining work, torque, ground speed, velocity, force) Sample problem: Investigate the dot products vector a •(vector a x vector b) and vector b •(vector a x vector b) for any two vectors vector a and vector b in three-space. What property of the cross product vector a x vector b does this verify?

3. Describing Lines and Planes Using Linear Equations

- ☐ **GA3.01 CR2007** — 3.1 recognize that the solution points (x, y) in two-space of a single linear equation in two variables form a line and that the solution points (x, y) in two-space of a system of two linear equations in two variables determine the point of intersection of two lines, if the lines are not coincident or parallel Sample problem: Describe algebraically the situations in two-space in which the solution points (x, y) of a system of two linear equations in two variables do not determine a point.

FIND RESULTS: 418 expectations were found
containing the term(s): **"sample problem"**
within: **Gr.7, Gr.8, Gr.9, Gr.10, Gr.11, Gr.12**
within: **Mathematics**

☐ **GA3.02** **CR2007** 3.2 determine, through investigation with technology (i.e., 3-D graphing software) and without technology, that the solution points (x, y, z) in three-space of a single linear equation in three variables form a plane and that the solution points (x, y, z) in three-space of a system of two linear equations in three variables form the line of intersection of two planes, if the planes are not coincident or parallel Sample problem: Use spatial reasoning to compare the shapes of the solutions in three-space with the shapes of the solutions in two-space for each of the linear equations x = 0, y = 0, and y = x. For each of the equations z = 5, y – z = 3, and x + z = 1, describe the shape of the solution points (x, y, z) in three-space. Verify the shapes of the solutions in three-space using technology.

4. Describing Lines and Planes Using Scalar, Vector, and Parametric Equations

☐ **GA4.02** **CR2007** 4.2 recognize that a line in three-space cannot be represented by a scalar equation, and represent a line in three-space using the scalar equations of two intersecting planes and using vector and parametric equations (e.g., given a direction vector and a point on the line, or given two points on the line) Sample problem: Represent the line passing through (3, 2, – 1) and (0, 2, 1) with the scalar equations of two intersecting planes, with a vector equation, and with parametric equations.

☐ **GA4.03** **CR2007** 4.3 recognize a normal to a plane geometrically (i.e., as a vector perpendicular to the plane) and algebraically [e.g., one normal to the plane 3x + 5y – 2z = 6 is (3, 5, –2)], and determine, through investigation, some geometric properties of the plane (e.g., the direction of any normal to a plane is constant; all scalar multiples of a normal to a plane are also normals to that plane; three non-collinear points determine a plane; the resultant, or sum, of any two vectors in a plane also lies in the plane) Sample problem: How does the relationship vector a •(vector b x vector c) = 0 help you determine whether three non-parallel planes intersect in a point, if vector a, vector b, and vector c represent normals to the three planes?

☐ **GA4.04** **CR2007** 4.4 recognize a scalar equation for a plane in three-space to be an equation of the form Ax + By + Cz + D = 0 whose solution points make up the plane, determine the intersection of three planes represented using scalar equations by solving a system of three linear equations in three unknowns algebraically (e.g., by using elimination or substitution), and make connections between the algebraic solution and the geometric configuration of the three planes Sample problem: Determine the equation of a plane P_3 that intersects the planes P_1, x + y + z = 1, and P_2, x – y + z = 0, in a single point. Determine the equation of a plane P_4 that intersects P_1 and P_2 in more than one point.

☐ **GA4.05** **CR2007** 4.5 determine, using properties of a plane, the scalar, vector, and parametric equations of a plane Sample problem: Determine the scalar, vector, and parametric equations of the plane that passes through the points (3, 2, 5), (0, – 2, 2), and (1, 3, 1).

☐ **GA4.06** **CR2007** 4.6 determine the equation of a plane in its scalar, vector, or parametric form, given another of these forms Sample problem: Represent the plane vector r = (2, 1, 0) + s(1, – 1, 3) + t(2, 0, – 5), where s and t are real numbers, with a scalar equation.

☐ **GA4.07** **CR2007** 4.7 solve problems relating to lines and planes in three-space that are represented in a variety of ways (e.g., scalar, vector, parametric equations) and involving distances (e.g., between a point and a plane; between two skew lines) or intersections (e.g., of two lines, of a line and a plane), and interpret the result geometrically Sample problem: Determine the intersection of the perpendicular line drawn from the point A(– 5, 3, 7) to the plane vector v = (0, 0, 2) + t(–1,1, 3) + s(2, 0, – 3), and determine the distance from point A to the plane.

Gr.12   Mathematics of Data Management---A. COUNTING AND PROBABILITY   MDM 4U

1. Solving Probability Problems Involving Discrete Sample Spaces

☐ **CP1.03** **CR2007** 1.3 determine the theoretical probability, Pi (i.e., a value from 0 to 1), of each outcome of a discrete sample space (e.g., in situations in which all outcomes are equally likely), recognize that the sum of the probabilities of the outcomes is 1 (i.e., for n outcomes, $P_1 + P_2 + P_3 + ... + P_n = 1$), recognize that the probabilities P_i form the probability distribution associated with the sample space, and solve related problems Sample problem: An experiment involves rolling two number cubes and determining the sum. Calculate the theoretical probability of each outcome, and verify that the sum of the probabilities is 1.

FIND RESULTS: 418 expectations were found
containing the term(s): **"sample problem"**
within: **Gr.7, Gr.8, Gr.9, Gr.10, Gr.11, Gr.12**
within: **Mathematics**

☐ **CP1.04** **CR2007** 1.4 determine, through investigation using class-generated data and technology-based simulation models (e.g., using a random-number generator on a spreadsheet or on a graphing calculator; using dynamic statistical software to simulate repeated trials in an experiment), the tendency of experimental probability to approach theoretical probability as the number of trials in an experiment increases (e.g., "If I simulate tossing two coins 1000 times using technology, the experimental probability that I calculate for getting two tails on the two tosses is likely to be closer to the theoretical probability of 1/4 than if I simulate tossing the coins only 10 times")
Sample problem: Calculate the theoretical probability of rolling a 2 on a single roll of a number cube. Simulate rolling a number cube, and use the simulation results to calculate the experimental probabilities of rolling a 2 over 10, 20, 30, ..., 200 trials. Graph the experimental probabilities versus the number of trials, and describe any trend.

2. Solving Problems Using Counting Principles

☐ **CP2.01** **CR2007** 2.1 recognize the use of permutations and combinations as counting techniques with advantages over other counting techniques (e.g., making a list; using a tree diagram; making a chart; drawing a Venn diagram), distinguish between situations that involve the use of permutations and those that involve the use of combinations (e.g., by considering whether or not order matters), and make connections between, and calculate, permutations and combinations Sample problem: An organization with 10 members is considering two leadership models. One involves a steering committee with 4 members of equal standing. The other is an executive committee consisting of a president, vice-president, secretary, and treasurer. Determine the number of ways of selecting the executive committee from the 10 members and, using this number, the number of ways of selecting the steering committee from the 10 members. How are the calculations related? Use the calculations to explain the relationship between permutations and combinations.

☐ **CP2.02** **CR2007** 2.2 solve simple problems using techniques for counting permutations and combinations, where all objects are distinct, and express the solutions using standard combinatorial notation [e.g., n!, P(n, r), C(n, r)] Sample problem: In many Aboriginal communities, it is common practice for people to shake hands when they gather. Use combinations to determine the total number of handshakes when 7 people gather, and verify using a different strategy.

☐ **CP2.04** **CR2007** 2.4 make connections, through investigation, between combinations (i.e., n choose r) and Pascal's triangle [e.g., between C(2, r) and row 3 of Pascal's triangle, between C(n, 2) and diagonal 3 of Pascal's triangle] Sample problem: A school is 5 blocks west and 3 blocks south of a student's home. Determine, in a variety of ways (e.g., by drawing the routes, by using Pascal's triangle, by using combinations), how many different routes the student can take from home to the school by going west or south at each corner.

☐ **CP2.05** **CR2007** 2.5 solve probability problems using counting principles for situations involving equally likely outcomes Sample problem: Two marbles are drawn randomly from a bag containing 12 green marbles and 16 red marbles. What is the probability that the two marbles are both green if the first marble is replaced? If the first marble is not replaced?

Gr.12 Mathematics of Data Management---B. PROBABILITY DISTRIBUTIONS MDM 4U

1. Understanding Probability Distributions for Discrete Random Variables

☐ **PD1.02** **CR2007** 1.2 calculate the expected value for a given probability distribution [i.e., using $E(X) = \Sigma xP(X = x)$], interpret the expected value in applications, and make connections between the expected value and the weighted mean of the values of the discrete random variable Sample problem: Of six cases, three each hold $1, two each hold $1000, and one holds $100 000. Calculate the expected value and interpret its meaning. Make a conjecture about what happens to the expected value if you add $10 000 to each case or if you multiply the amount in each case by 10. Verify your conjectures.

☐ **PD1.03** **CR2007** 1.3 represent a probability distribution graphically using a probability histogram (i.e., a histogram on which each rectangle has a base of width 1, centred on the value of the discrete random variable, and a height equal to the probability associated with the value of the random variable), and make connections between the frequency histogram and the probability histogram (e.g., by comparing their shapes) Sample problem: For the situation involving the rolling of two number cubes and determining the sum, identify the discrete random variable and generate the related probability histogram. Determine the total area of the bars in the histogram and explain your result.

FIND RESULTS: 418 expectations were found
containing the term(s): **"sample problem"**
within: **Gr.7, Gr.8, Gr.9, Gr.10, Gr.11, Gr.12**
within: **Mathematics**

☐ **PD1.04** **CR2007**
1.4 recognize conditions (e.g., independent trials) that give rise to a random variable that follows a binomial probability distribution, calculate the probability associated with each value of the random variable, represent the distribution numerically using a table and graphically using a probability histogram, and make connections to the algebraic representation $P(X = x) = C(n, x)p^x (1 – p)^{n-x}$ Sample problem: A light-bulb manufacturer estimates that 0.5% of the bulbs manufactured are defective. Generate and graph the probability distribution for the random variable that represents the number of defective bulbs in a set of 4 bulbs.

☐ **PD1.06** **CR2007**
1.6 compare, with technology and using numeric and graphical representations, the probability distributions of discrete random variables (e.g., compare binomial distributions with the same probability of success for increasing numbers of trials; compare the shapes of a hypergeometric distribution and a binomial distribution) Sample problem: Compare the probability distributions associated with drawing 0, 1, 2, or 3 face cards when a card is drawn 3 times from a standard deck with replacement (i.e., the card is replaced after each draw) and without replacement (i.e., the card is not replaced after each draw).

☐ **PD1.07** **CR2007**
1.7 solve problems involving probability distributions (e.g., uniform, binomial, hypergeometric), including problems arising from real-world applications Sample problem: The probability of a business person cancelling a reservation at La Place Pascal hotel is estimated to be 8%. Generate and graph the probability distribution for the discrete random variable that represents the number of business people cancelling when there are 10 reservations. Use the probability distribution to determine the probability of at least 4 of the 10 reservations being cancelled.

2. Understanding Probability Distributions for Continuous Random Variables

☐ **PD2.07** **CR2007**
2.7 make connections, through investigation using dynamic statistical software, between the normal distribution and the binomial and hypergeometric distributions for increasing numbers of trials of the discrete distributions (e.g., recognizing that the shape of the hypergeometric distribution of the number of males on a 4-person committee selected from a group of people more closely resembles the shape of a normal distribution as the size of the group from which the committee was drawn increases) Sample problem: Explain how the total area of a probability histogram for a binomial distribution allows you to predict the area under a normal probability distribution curve.

☐ **PD2.08** **CR2007**
2.8 recognize a z-score as the positive or negative number of standard deviations from the mean to a value of the continuous random variable, and solve probability problems involving normal distributions using a variety of tools and strategies (e.g., calculating a z-score and reading a probability from a table; using technology to determine a probability), including problems arising from real-world applications Sample problem: The heights of 16-month-old maple seedlings are normally distributed with a mean of 32 cm and a standard deviation of 10.2 cm. What is the probability that the height of a randomly selected seedling will be between 24.0 cm and 38.0 cm?

Gr.12 Mathematics of Data Management---C. ORGANIZATION OF DATA FOR ANALYSIS MDM 4U

1. Understanding Data Concepts

☐ **OD1.02** **CR2007**
1.2 recognize and explain reasons why variability is inherent in data (e.g., arising from limited accuracy in measurement or from variations in the conditions of an experiment; arising from differences in samples in a survey), and distinguish between situations that involve one variable and situations that involve more than one variable Sample problem: Use the Census at School database to investigate variability in the median and mean of, or a proportion estimated from, equal-sized random samples of data on a topic such as the percentage of students who do not smoke or who walk to school, or the average height of people of a particular age. Compare the median and mean of, or a proportion estimated from, samples of increasing size with the median and mean of the population or the population proportion.

2. Collecting and Organizing Data

☐ **OD2.02** **CR2007**
2.2 explain the distinction between the terms population and sample, describe the characteristics of a good sample, explain why sampling is necessary (e.g., time, cost, or physical constraints), and describe and compare some sampling techniques (e.g., simple random, systematic, stratified, convenience, voluntary) Sample problem: What are some factors that a manufacturer should consider when determining whether to test a sample or the entire population to ensure the quality of a product?

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FIND RESULTS: 418 expectations were found
containing the term(s): **"sample problem"**
within: **Gr.7, Gr.8, Gr.9, Gr.10, Gr.11, Gr.12**
within: **Mathematics**

- ☐ **OD2.04** **CR2007** — 2.4 describe characteristics of an effective survey (e.g., by giving consideration to ethics, privacy, the need for honest responses, and possible sources of bias, including cultural bias), and design questionnaires (e.g., for determining if there is a relationship between a person's age and their hours per week of Internet use, between marks and hours of study, or between income and years of education) or experiments (e.g., growth of plants under different conditions) for gathering data Sample problem: Give examples of concerns that could arise from an ethical review of surveys generated by students in your school.

Gr.12 Mathematics of Data Management---D. STATISTICAL ANALYSIS MDM 4U

1. Analysing One-Variable Data

- ☐ **SA1.04** **CR2007** — 1.4 interpret, for a normally distributed population, the meaning of a statistic qualified by a statement describing the margin of error and the confidence level (e.g., the meaning of a statistic that is accurate to within 3 percentage points, 19 times out of 20), and make connections, through investigation using technology (e.g., dynamic statistical software), between the sample size, the margin of error, and the confidence level (e.g., larger sample sizes create higher confidence levels for a given margin of error) Sample problem: Use census data from Statistics Canada to investigate, using dynamic statistical software, the minimum sample size such that the proportion of the sample opting for a particular consumer or voting choice is within 3 percentage points of the proportion of the population, 95% of the time (i.e., 19 times out of 20).

2. Analysing Two-Variable Data

- ☐ **SA2.01** **CR2007** — 2.1 recognize that the analysis of two-variable data involves the relationship between two attributes, recognize the correlation coefficient as a measure of the fit of the data to a linear model, and determine, using technology, the relevant numerical summaries (e.g., summary tables such as contingency tables; correlation coefficients) Sample problem: Organize data from Statistics Canada to analyse gender differences (e.g., using contingency tables; using correlation coefficients) related to a specific set of characteristics (e.g., average income, hours of unpaid housework).

3. Evaluating Validity

- ☐ **SA3.02** **CR2007** — 3.2 assess the validity of conclusions presented in the media by examining sources of data, including Internet sources (i.e., to determine whether they are authoritative, reliable, unbiased, and current), methods of data collection, and possible sources of bias (e.g., sampling bias, non-response bias, cultural bias in a survey question), and by questioning the analysis of the data (e.g., whether there is any indication of the sample size in the analysis) and conclusions drawn from the data (e.g., whether any assumptions are made about cause and effect) Sample problem: The headline that accompanies the following graph says “Big Increase in Profits". Suggest reasons why this headline may or may not be true. (graph omitted from page 121)

Gr.11 Mathematics for Work and Everyday Life---Earning and Purchasing MEL 3E

Earning

- ☐ **EP1.04** **CR2006** — – solve problems, using technology (e.g., calculator, spreadsheet), and make decisions involving different remuneration methods and schedules (Sample problem: Two sales positions are available in sportswear stores. One pays an hourly rate of $11.25 for 40 h per week. The other pays a weekly salary of $375 for the same number of hours, plus a commission of 5% of sales. Under what conditions would each position be the better choice?).

Describing Purchasing Power

- ☐ **EP2.02** **CR2006** — – estimate and compare, using current secondary data (e.g., federal tax tables), the percent of total earnings deducted through government payroll deductions for various benchmarks (e.g., $15 000, $20 000, $25 000) (Sample problem: Compare the percent of total earnings deducted through government payroll deductions for total earnings of $15 000 and $45 000.);

Purchasing

FIND RESULTS: 418 expectations were found
containing the term(s): **"sample problem"**
within: **Gr.7, Gr.8, Gr.9, Gr.10, Gr.11, Gr.12**
within: **Mathematics**

- ☐ **EP3.03 CR2006** – describe and compare a variety of strategies for estimating sales tax (e.g., estimate the sales tax on most purchases in Ontario by estimating 10% of the purchase price and adding about a third of this estimate, rather than estimating the PST and GST separately), and use a chosen strategy to estimate the after-tax cost of common items (Sample problem: You purchase three items for $8.99 each and one item for $4.99. Estimate the after-tax total.);
- ☐ **EP3.06 CR2006** – estimate the change from an amount offered to pay a charge (Sample problem: Estimate the change from the $20 offered to pay a charge of $13.87.);
- ☐ **EP3.07 CR2006** – make the correct change from an amount offered to pay a charge, using currency manipulatives (Sample problem: Use currency manipulatives to explain why someone might offer $15.02, rather than $15.00, to pay a charge of $13.87.);
- ☐ **EP3.08 CR2006** – compare the unit prices of related items to help determine the best buy (Sample problem: Investigate whether or not purchasing larger quantities always results in a lower unit price.);
- ☐ **EP3.09 CR2006** – describe and compare, for different types of transactions, the extra costs that may be associated with making purchases (e.g., interest costs, exchange rates, shipping and handling costs, customs duty, insurance) (Sample problem: What are the various costs included in the final total for purchasing a digital audio player online from an American source? Using an online calculator, calculate the final cost, and describe how it compares with the cost of the purchase from a major retailer in Ontario.);
- ☐ **EP3.10 CR2006** – make and justify a decision regarding the purchase of an item, using various criteria (e.g., extra costs, such as shipping costs and transaction fees; quality and quantity of the item; shelf life of the item; method of purchase, such as online versus local) under various circumstances (e.g., not having access to a vehicle; living in a remote community; having limited storage space) (Sample problem: I have to take 100 mL of a liquid vitamin supplement every morning. I can buy a 100 mL size for $6.50 or a 500 mL size for $25.00. If the supplement keeps in the refrigerator for only 72 h, investigate which size is the better buy. Explain your reasoning.).

Gr.11 Mathematics for Work and Everyday Life---Saving, Investing, and Borrowing MEL 3E

Comparing Financial Services

- ☐ **SI1.03 CR2006** – read and interpret transaction codes and entries from various financial statements (e.g., bank statement, credit card statement, passbook, automated banking machine printout, online banking statement, account activity report), and explain ways of using the information to manage personal finances (Sample problem: Examine a credit card statement and a bank statement for one individual, and comment on the individual's financial situation.).

Saving and Investing

- ☐ **SI2.02 CR2006** – determine, through investigation using technology, the compound interest for a given investment, using repeated calculations of simple interest for no more than 6 compounding periods (Sample problem: Someone deposits $5000 at 4% interest per annum, compounded semi-annually. How much interest accumulates in 3 years?);
- ☐ **SI2.04 CR2006** – determine, through investigation using technology (e.g., a TVM Solver in a graphing calculator or on a website), the effect on the future value of a compound interest investment of changing the total length of time, the interest rate, or the compounding period (Sample problem: Compare the results at age 40 of making a deposit of $1000 at age 20 or a deposit of $2000 at age 30, if both investments pay 6% interest per annum, compounded monthly.);

Borrowing

- ☐ **SI3.01 CR2006** – gather, interpret, and compare information about the effects of carrying an outstanding balance on a credit card at current interest rates (Sample problem: Describe ways of minimizing the cost of carrying an outstanding balance on a credit card.);

Gr.11 Mathematics for Work and Everyday Life---Transportation and Travel MEL 3E

Owning and Operating a Vehicle

FIND RESULTS: 418 expectations were found
containing the term(s): **"sample problem"**
within: **Gr.7, Gr.8, Gr.9, Gr.10, Gr.11, Gr.12**
within: **Mathematics**

- ☐ **TT1.03 CR2006** – gather and interpret information about the procedures and costs involved in insuring a vehicle (e.g., car, motorcycle, snowmobile) and the factors affecting insurance rates (e.g., gender, age, driving record, model of vehicle, use of vehicle), and compare the insurance costs for different categories of drivers and for different vehicles (Sample problem: Use automobile insurance websites to investigate the degree to which the type of car and the age and gender of the driver affect insurance rates.);
- ☐ **TT1.04 CR2006** – gather and interpret information about the costs (e.g., monthly payments, insurance, depreciation, maintenance, miscellaneous expenses) of purchasing or leasing a new vehicle or purchasing a used vehicle, and describe the conditions that favour each alternative (Sample problem: Compare the costs of buying a new car, leasing the same car, and buying an older model of the same car.);
- ☐ **TT1.06 CR2006** – identify and describe costs (e.g., gas consumption, depreciation, insurance, maintenance) and benefits (e.g., convenience, increased profit) of owning and operating a vehicle for business (Sample problem: Your employer pays 35 cents/km for you to use your car for work. Discuss how you would determine whether or not this is fair compensation.);
- ☐ **TT1.07 CR2006** – solve problems, using technology (e.g., calculator, spreadsheet), that involve the fixed costs (e.g., licence fee, insurance) and variable costs (e.g., maintenance, fuel) of owning and operating a vehicle (Sample problem: The rate at which a car consumes gasoline depends on the speed of the car. Use a given graph of gasoline consumption, in litres per 100 km, versus speed, in kilometres per hour, to determine how much gasoline is used to drive 500 km at speeds of 80 km/h, 100 km/h, and 120 km/h. Use the current price of gasoline to calculate the cost of driving 500 km at each of these speeds.).

Travelling by Automobile

- ☐ **TT2.01 CR2006** – determine distances represented on maps (e.g., provincial road map, local street map, Web-based maps), using given scales (Sample problem: Compare the driving distances between two points on the same map by two different routes.);
- ☐ **TT2.04 CR2006** – solve problems involving the cost of travelling by automobile for personal or business purposes (Sample problem: Determine and justify a cost-effective delivery route for ten deliveries to be made in a given area over two days.).

Comparing Modes of Transportation

- ☐ **TT3.01 CR2006** – gather, interpret, and describe information about the impact (e.g., monetary, health, environmental) of daily travel (e.g., to work and/or school), using available means (e.g., car, taxi, motorcycle, public transportation, bicycle, walking) (Sample problem: Discuss the impact if 100 students decided to walk the 3 km distance to school instead of taking a school bus.);
- ☐ **TT3.02 CR2006** – gather, interpret, and compare information about the costs (e.g., insurance; extra charges based on distance travelled) and conditions (e.g., one-way or return; drop-off time and location; age of the driver; required type of driver's licence) involved in renting a car, truck, or trailer, and use the information to justify a choice of rental vehicle (Sample problem: You want to rent a trailer or a truck to help you move to a new apartment. Investigate the costs and describe the conditions that favour each option.);
- ☐ **TT3.04 CR2006** – solve problems involving the comparison of information concerning transportation by airplane, train, bus, and automobile in terms of various factors (e.g., cost, time, convenience) (Sample problem: Investigate the cost of shipping a computer from Thunder Bay to Windsor by airplane, train, or bus. Describe the conditions that favour each alternative.).

Gr.12 Mathematics for Work and Everyday Life---A. REASONING WITH DATA MEL 4E

1. Interpreting and Displaying Data

- ☐ **RD1.02 CR2007** 1.2 explain the distinction between the terms population and sample, describe the characteristics of a good sample, and explain why sampling is necessary (e.g., time, cost, or physical constraints) Sample problem: What are some factors that a manufacturer should consider when determining whether to test a sample or the entire population to ensure the quality of a product?

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FIND RESULTS: 418 expectations were found
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within: **Gr.7, Gr.8, Gr.9, Gr.10, Gr.11, Gr.12**
within: **Mathematics**

- ☐ **RD1.03** **CR2007** 1.3 collect categorical data from primary sources, through experimentation involving observation (e.g., by tracking food orders in restaurants offering healthy food options) or measurement, or from secondary sources (e.g., Internet databases, newspapers, magazines), and organize and store the data using a variety of tools (e.g., spreadsheets, dynamic statistical software) Sample problem: Observe cars that pass through a nearby intersection. Collect data on seatbelt usage or the number of passengers per car.
- ☐ **RD1.07** **CR2007** 1.7 explain how the media, the advertising industry, and others (e.g., marketers, pollsters) use and misuse statistics (e.g., as represented in graphs) to promote a certain point of view (e.g., by making general statements based on small samples; by making statements using general population statistics without reference to data specific to minority groups) Sample problem: The headline that accompanies the following graph says Big Increase in Profits". Suggest reasons why this headline may or may not be true. (omitted graph from page 149)"

2. Investigating Probability

- ☐ **RD2.05** **CR2007** 2.5 determine, through investigation using class-generated data and technology-based simulation models (e.g., using a random-number generator on a spreadsheet or on a graphing calculator), the tendency of experimental probability to approach theoretical probability as the number of trials in an experiment increases (e.g., "If I simulate tossing a coin 1000 times using technology, the experimental probability that I calculate for getting tails in any one toss is likely to be closer to the theoretical probability than if I simulate tossing the coin only 10 times")
  Sample problem: Calculate the theoretical probability of rolling a 2 on a number cube. Simulate rolling a number cube, and use the simulation to calculate the experimental probability of rolling a 2 after 10, 20, 30, ..., 200 trials. Graph the experimental probability versus the number of trials, and describe any trend.
- ☐ **RD2.06** **CR2007** 2.6 interpret information involving the use of probability and statistics in the media, and describe how probability and statistics can help in making informed decisions in a variety of situations (e.g., weighing the risk of injury when considering different occupations; using a weather forecast to plan outdoor activities; using sales data to stock a clothing store with appropriate styles and sizes) Sample problem: A recent study on youth gambling suggests that approximately 30% of adolescents gamble on a weekly basis. Investigate and describe the assumptions that people make about the probability of winning when they gamble. Describe other factors that encourage gambling and problems experienced by people with a gambling addiction.

Gr.12 Mathematics for Work and Everyday Life---C. APPLICATIONS OF MEASUREMENT MEL 4E

1. Measuring and Estimating

- ☐ **AM1.02** **CR2007** 1.2 estimate lengths, distances, and capacities in metric units and in imperial units by applying personal referents (e.g., the width of a finger is approximately 1 cm; the length of a piece of standard loose-leaf paper is about 1 ft; the capacity of a pop bottle is 2 L) Sample problem: Based on an estimate of the length of your stride, estimate how far it is to the nearest fire exit from your math classroom, and compare your estimate with the measurement you get using a pedometer.
- ☐ **AM1.03** **CR2007** 1.3 estimate quantities (e.g., bricks in a pile, time to complete a job, people in a crowd), and describe the strategies used Sample problem: Look at digital photos that show large quantities of items, and estimate the numbers of items in the photos.
- ☐ **AM1.05** **CR2007** 1.5 convert measures between systems (e.g., centimetres and inches, pounds and kilograms, square feet and square metres, litres and U.S. gallons, kilometres and miles, cups and millilitres, millilitres and teaspoons, degrees Celsius and degrees Fahrenheit), as required within applications that arise from familiar contexts Sample problem: Compare the price of gasoline in your community with the price of gasoline in a community in the United States.

2. Applying Measurement and Design

- ☐ **AM2.02** **CR2007** 2.2 apply the concept of perimeter in familiar contexts (e.g., baseboard, fencing, door and window trim) Sample problem: Which room in your home required the greatest, and which required the least, amount of baseboard? What is the difference in the two amounts?
- ☐ **AM2.03** **CR2007** 2.3 estimate the areas and volumes of irregular shapes and figures, using a variety of strategies (e.g., counting grid squares; displacing water) Sample problem: Draw an outline of your hand and estimate the area.

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- ☐ **AM2.04** **CR2007** 2.4 solve problems involving the areas of rectangles, triangles, and circles, and of related composite shapes, in situations arising from real-world applications Sample problem: A car manufacturer wants to display three of its compact models in a triangular arrangement on a rotating circular platform. Calculate a reasonable area for this platform, and explain your assumptions and reasoning.
- ☐ **AM2.05** **CR2007** 2.5 solve problems involving the volumes and surface areas of rectangular prisms, triangular prisms, and cylinders, and of related composite figures, in situations arising from real-world applications Sample problem: Compare the volumes of concrete needed to build three steps that are 4 ft wide and that have the cross-sections shown below. Explain your assumptions and reasoning. (omitted graph from page 154)
- ☐ **AM2.06** **CR2007** 2.6 construct a two-dimensional scale drawing of a familiar setting (e.g., classroom, flower bed, playground) on grid paper or using design or drawing software Sample problem: Your family is moving to a new house with a living room that is 16 ft by 10 ft. Cut out and label simple geometric shapes, drawn to scale, to represent every piece of furniture in your present living room. Place all of your cut-outs on a scale drawing of the new living room to find out if the furniture will fit appropriately (e.g., allowing adequate space to move around).
- ☐ **AM2.07** **CR2007** 2.7 construct, with reasonable accuracy, a three-dimensional scale model of an object or environment of personal interest (e.g., appliance, room, building, garden, bridge) Sample problem: Design an innovative combination of two appliances or two other consumer products (e.g., a camera and a cellphone, a refrigerator and a television), and construct a three-dimensional scale model.
- ☐ **AM2.08** **CR2007** 2.8 investigate, plan, design, and prepare a budget for a household improvement (e.g., landscaping a property; renovating a room), using appropriate technologies (e.g., design or decorating websites, design or drawing software, spreadsheet) Sample problem: Plan, design, and prepare a budget for the renovation of a 12-ft by 12-ft bedroom for under $2000. The renovations could include repainting the walls, replacing the carpet with hardwood flooring, and refurnishing the room.

3. Solving Measurement Problems Using Proportional Reasoning

- ☐ **AM3.02** **CR2007** 3.2 identify situations in which it is useful to make comparisons using unit rates, and solve problems that involve comparisons of unit rates Sample problem: If 500 mL of juice costs $2.29 and 750 mL of the same juice costs $3.59, which size is the better buy? Explain your reasoning.
- ☐ **AM3.04** **CR2007** 3.4 identify and describe the possible consequences (e.g., overdoses of medication; seized engines; ruined clothing; cracked or crumbling concrete) of errors in proportional reasoning (e.g., not recognizing the importance of maintaining proportionality; not correctly calculating the amount of each component in a mixture) Sample problem: Age, gender, body mass, body chemistry, and habits such as smoking are some factors that can influence the effectiveness of a medication. For which of these factors might doctors use proportional reasoning to adjust the dosage of medication? What are some possible consequences of making the adjustments incorrectly?
- ☐ **AM3.05** **CR2007** 3.5 solve problems involving proportional reasoning in everyday life (e.g., applying fertilizers; mixing gasoline and oil for use in small engines; mixing cement; buying plants for flower beds; using pool or laundry chemicals; doubling recipes; estimating cooking time from the time needed per pound; determining the fibre content of different sizes of food servings) Sample problem: Bring the label from a large can of stew to class. Use the information on the label to calculate how many calories and how much fat you would consume if you ate the whole can for dinner. Then search out information on a form of exercise you could choose for burning all those calories. For what length of time would you need to exercise?
- ☐ **AM3.06** **CR2007** 3.6 solve problems involving proportional reasoning in work-related situations (e.g., calculating overtime pay; calculating pay for piecework; mixing concrete for small or large jobs) Sample problem: Coiled pipe from the United States is delivered in 200-ft lengths. Your company needs pipe in 3.7-m sections. How many sections can you make from each 200-ft length?

Gr.9 Foundations of Mathematics---Number Sense and Algebra MFM 1P

Solving Problems Involving Proportional Reasoning

- ☐ **NA1.02** **SQC2005** – represent, using equivalent ratios and proportions, directly proportional relationships arising from realistic situations (Sample problem:You are building a skateboard ramp whose ratio of height to base must be 2:3.Write a proportion that could be used to determine the base if the height is 4.5 m.);

- ☐ **NA1.03 SQC2005** – solve for the unknown value in a proportion, using a variety of methods (e.g., concrete materials, algebraic reasoning, equivalent ratios, constant of proportionality) (Sample problem: Solve x/4 = 15/20.);
- ☐ **NA1.05 SQC2005** – solve problems involving ratios, rates, and directly proportional relationships in various contexts (e.g., currency conversions, scale drawings, measurement), using a variety of methods (e.g., using algebraic reasoning, equivalent ratios, a constant of proportionality; using dynamic geometry software to construct and measure scale drawings) (Sample problem: Simple interest is directly proportional to the amount invested. If Luis invests $84 for one year and earns $1.26 in interest, how much would he earn in interest if he invested $235 for one year?);
- ☐ **NA1.06 SQC2005** – solve problems requiring the expression of percents, fractions, and decimals in their equivalent forms (e.g., calculating simple interest and sales tax; analysing data) (Sample problem: Of the 29 students in a Grade 9 math class, 13 are taking science this semester. If this class is representative of all the Grade 9 students in the school, estimate and calculate the percent of the 236 Grade 9 students who are taking science this semester. Estimate and calculate the number of Grade 9 students this percent represents.).

Simplifying Expressions and Solving Equations

- ☐ **NA2.04 SQC2005** – substitute into and evaluate algebraic expressions involving exponents (i.e., evaluate expressions involving natural-number exponents with rational-number bases) [e.g., evaluate $(3/2)^3$ by hand and 9.8^3 by using a calculator]) (Sample problem: A movie theatre wants to compare the volumes of popcorn in two containers, a cube with edge length 8.1 cm and a cylinder with radius 4.5 cm and height 8.0 cm. Which container holds more popcorn?);* *The knowledge and skills described in this expectation are to be introduced as needed and applied and consolidated throughout the course.
- ☐ **NA2.07 SQC2005** – solve first-degree equations with nonfractional coefficients, using a variety of tools (e.g., computer algebra systems, paper and pencil) and strategies (e.g., the balance analogy, algebraic strategies) (Sample problem: Solve 2x + 7 = 6x – 1 using the balance analogy.);
- ☐ **NA2.08 SQC2005** – substitute into algebraic equations and solve for one variable in the first degree (e.g., in relationships, in measurement) (Sample problem: The perimeter of a rectangle can be represented as P = 2l + 2w. If the perimeter of a rectangle is 59 cm and the width is 12 cm, determine the length.).

Gr.9 Foundations of Mathematics---Linear Relations MFM 1P

Using Data Management to Investigate Relationships

- ☐ **LR1.01 SQC2005** – interpret the meanings of points on scatter plots or graphs that represent linear relations, including scatter plots or graphs in more than one quadrant [e.g., on a scatter plot of height versus age, interpret the point (13, 150) as representing a student who is 13 years old and 150 cm tall; identify points on the graph that represent students who are taller and younger than this student] (Sample problem: Given a graph that represents the relationship of the Celsius scale and the Fahrenheit scale, determine the Celsius equivalent of –5°F.);
- ☐ **LR1.02 SQC2005** – pose problems, identify variables, and formulate hypotheses associated with relationships between two variables (Sample problem: Does the rebound height of a ball depend on the height from which it was dropped?);
- ☐ **LR1.03 SQC2005** – carry out an investigation or experiment involving relationships between two variables, including the collection and organization of data, using appropriate methods, equipment, and/or technology (e.g., surveying; using measuring tools, scientific probes, the Internet) and techniques (e.g., making tables, drawing graphs) (Sample problem: Perform an experiment to measure and record the temperature of ice water in a plastic cup and ice water in a thermal mug over a 30 min period, for the purpose of comparison. What factors might affect the outcome of this experiment? How could you change the experiment to account for them?);

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- ☐ **LR1.04** **SQC2005** – describe trends and relationships observed in data, make inferences from data, compare the inferences with hypotheses about the data, and explain any differences between the inferences and the hypotheses (e.g., describe the trend observed in the data. Does a relationship seem to exist? Of what sort? Is the outcome consistent with your hypothesis? Identify and explain any outlying pieces of data. Suggest a formula that relates the variables. How might you vary this experiment to examine other relationships?) (Sample problem: Hypothesize the effect of the length of a pendulum on the time required for the pendulum to make five full swings. Use data to make an inference. Compare the inference with the hypothesis. Are there other relationships you might investigate involving pendulums?).

Determining Characteristics of Linear Relations

- ☐ **LR2.01** **SQC2005** – construct tables of values and graphs, using a variety of tools (e.g., graphing calculators, spreadsheets, graphing software, paper and pencil), to represent linear relations derived from descriptions of realistic situations (Sample problem: Construct a table of values and a graph to represent a monthly cellphone plan that costs $25, plus $0.10 per minute of airtime.);
- ☐ **LR2.02** **SQC2005** – construct tables of values, scatter plots, and lines or curves of best fit as appropriate, using a variety of tools (e.g., spreadsheets, graphing software, graphing calculators, paper and pencil), for linearly related and non-linearly related data collected from a variety of sources (e.g., experiments, electronic secondary sources, patterning with concrete materials) (Sample problem: Collect data, using concrete materials or dynamic geometry software, and construct a table of values, a scatter plot, and a line or curve of best fit to represent the following relationships: the volume and the height for a square-based prism with a fixed base; the volume and the side length of the base for a square-based prism with a fixed height.);

Investigating Constant Rate of Change

- ☐ **LR3.03** **SQC2005** – compare the properties of direct variation and partial variation in applications, and identify the initial value (e.g., for a relation described in words, or represented as a graph or an equation) (Sample problem: Yoga costs $20 for registration, plus $8 per class.Tai chi costs $12 per class. Which situation represents a direct variation, and which represents a partial variation? For each relation, what is the initial value? Explain your answers.);

Connecting Various Representations of Linear Relations and Solving Problems Using the Representations

- ☐ **LR4.01** **SQC2005** – determine values of a linear relation by using a table of values, by using the equation of the relation, and by interpolating or extrapolating from the graph of the relation (Sample problem: The equation $H = 300 – 60t$ represents the height of a hot air balloon that is initially at 300 m and is descending at a constant rate of 60 m/min. Determine algebraically and graphically its height after 3.5 min.);
- ☐ **LR4.02** **SQC2005** – describe a situation that would explain the events illustrated by a given graph of a relationship between two variables (Sample problem: The walk of an individual is illustrated in the given graph, produced by a motion detector and a graphing calculator. Describe the walk [e.g., the initial distance from the motion detector, the rate of walk].);
- ☐ **LR4.04** **SQC2005** – solve problems that can be modelled with first-degree equations, and compare the algebraic method to other solution methods (e.g., graphing) (Sample problem: Bill noticed it snowing and measured that 5 cm of snow had already fallen. During the next hour, an additional 1.5 cm of snow fell. If it continues to snow at this rate, how many more hours will it take until a total of 12.5 cm of snow has accumulated?);
- ☐ **LR4.06** **SQC2005** – determine graphically the point of intersection of two linear relations, and interpret the intersection point in the context of an application (Sample problem: A video rental company has two monthly plans. Plan A charges a flat fee of $30 for unlimited rentals; Plan B charges $9, plus $3 per video. Use a graphical model to determine the conditions under which you should choose Plan A or Plan B.);
- ☐ **LR4.07** **SQC2005** – select a topic involving a two-variable relationship (e.g., the amount of your pay cheque and the number of hours you work; trends in sports salaries over time; the time required to cool a cup of coffee), pose a question on the topic, collect data to answer the question, and present its solution using appropriate representations of the data (Sample problem: Individually or in a small group, collect data on the cost compared to the capacity of computer hard drives. Present the data numerically, graphically, and [if linear] algebraically. Describe the results and any trends orally or by making a poster display or by using presentation software.).

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Gr.9 Foundations of Mathematics---Measurement and Geometry MFM 1P

Investigating the Optimal Values of Measurements of Rectangles

☐ **MG1.03 SQC2005** – solve problems that require maximizing the area of a rectangle for a fixed perimeter or minimizing the perimeter of a rectangle for a fixed area (Sample problem:You have 100 m of fence to enclose a rectangular area to be used for a snow sculpture competition. One side of the area is bounded by the school, so the fence is required for only three sides of the rectangle. Determine the dimensions of the maximum area that can be enclosed.).

Solving Problems Involving Perimeter, Area, and Volume

☐ **MG2.03 SQC2005** – solve problems involving the areas and perimeters of composite two-dimensional shapes (i.e., combinations of rectangles, triangles, parallelograms, trapezoids, and circles) (Sample problem: A new park is in the shape of an isosceles trapezoid with a square attached to the shortest side.The side lengths of the trapezoidal section are 200 m, 500 m, 500 m, and 800 m, and the side length of the square section is 200 m. If the park is to be fully fenced and sodded, how much fencing and sod are required?);

☐ **MG2.05 SQC2005** – solve problems involving the volumes of prisms, pyramids, cylinders, cones, and spheres (Sample problem: Break-bit Cereal is sold in a single-serving size, in a box in the shape of a rectangular prism of dimensions 5 cm by 4 cm by 10 cm. The manufacturer also sells the cereal in a larger size, in a box with dimensions double those of the smaller box. Make a hypothesis about the effect on the volume of doubling the dimensions.Test your hypothesis using the volumes of the two boxes, and discuss the result.).

Investigating and Applying Geometric Relationships

☐ **MG3.01 SQC2005** – determine, through investigation using a variety of tools (e.g., dynamic geometry software, concrete materials), and describe the properties and relationships of the interior and exterior angles of triangles, quadrilaterals, and other polygons, and apply the results to problems involving the angles of polygons (Sample problem:With the assistance of dynamic geometry software, determine the relationship between the sum of the interior angles of a polygon and the number of sides. Use your conclusion to determine the sum of the interior angles of a 20-sided polygon.);

Gr.10 Foundations of Mathematics---Measurement and Trigonometry MFM 2P

Solving Problems Involving Similar Triangles

☐ **MT1.03 SQC2005** – solve problems involving similar triangles in realistic situations (e.g., shadows, reflections, scale models, surveying) (Sample problem: Use a metre stick to determine the height of a tree, by means of the similar triangles formed by the tree, the metre stick, and their shadows.).

Solving Problems Involving the Trigonometry of Right Triangles

☐ **MT2.03 SQC2005** – solve problems involving the measures of sides and angles in right triangles in real-life applications (e.g., in surveying, in navigation, in determining the height of an inaccessible object around the school), using the primary trigonometric ratios and the Pythagorean theorem (Sample problem: Build a kite, using imperial measurements, create a clinometer to determine the angle of elevation when the kite is flown, and use the tangent ratio to calculate the height attained.);

Solving Problems Involving Surface Area and Volume, Using the Imperial and Metric Systems of Measurement

☐ **MT3.02 SQC2005** – perform everyday conversions between the imperial system and the metric system (e.g., millilitres to cups, centimetres to inches) and within these systems (e.g., cubic metres to cubic centimetres, square feet to square yards), as necessary to solve problems involving measurement (Sample problem: A vertical post is to be supported by a wooden pole, secured on the ground at an angle of elevation of 60°, and reaching 3 m up the post from its base. If wood is sold by the foot, how many feet of wood are needed to make the pole?);

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- [ ] **MT3.04** **SQC2005** – solve problems involving the surface areas of prisms, pyramids, and cylinders, and the volumes of prisms, pyramids, cylinders, cones, and spheres, including problems involving combinations of these figures, using the metric system or the imperial system, as appropriate (Sample problem: How many cubic yards of concrete are required to pour a concrete pad measuring 10 feet by 10 feet by 1 foot? If poured concrete costs $110 per cubic yard, how much does it cost to pour a concrete driveway requiring 6 pads?).

Gr.10 Foundations of Mathematics---Modelling Linear Relations MFM 2P

Manipulating and Solving Algebraic Equations

- [ ] **ML1.01** **SQC2005** – solve first-degree equations involving one variable, including equations with fractional coefficients (e.g. using the balance analogy, computer algebra systems, paper and pencil) (Sample problem: Solve x/2 + 4 = 3x – 1 and verify.);
- [ ] **ML1.02** **SQC2005** – determine the value of a variable in the first degree, using a formula (i.e., by isolating the variable and then substituting known values; by substituting known values and then solving for the variable) (e.g., in analytic geometry, in measurement) (Sample problem: A cone has a volume of 100 cm^3. The radius of the base is 3 cm. What is the height of the cone?);

Solving and Interpreting Systems of Linear Equations

- [ ] **ML3.01** **SQC2005** – determine graphically the point of intersection of two linear relations (e.g., using graph paper, using technology) (Sample problem: Determine the point of intersection of y + 2x = –5 and y = 2/3x + 3, using an appropriate graphing technique, and verify.);
- [ ] **ML3.02** **SQC2005** – solve systems of two linear equations involving two variables with integral coefficients, using the algebraic method of substitution or elimination (Sample problem: Solve y = 2x + 1, 3x + 2y = 16 for x and y algebraically, and verify algebraically and graphically.);
- [ ] **ML3.03** **SQC2005** – solve problems that arise from realistic situations described in words or represented by given linear systems of two equations involving two variables, by choosing an appropriate algebraic or graphical method (Sample problem: Maria has been hired by Company A with an annual salary, S dollars, given by S = 32 500 + 500a, where a represents the number of years she has been employed by this company. Ruth has been hired by Company B with an annual salary, S dollars, given by S = 28 000 + 1000a, where a represents the number of years she has been employed by that company. Describe what the solution of this system would represent in terms of Maria's salary and Ruth's salary. After how many years will their salaries be the same? What will their salaries be at that time?).

Gr.10 Foundations of Mathematics---Quadratic Relations of the Form y = ax2 + bx + c MFM 2P

Identifying Characteristics of Quadratic Relations

- [ ] **QR2.01** **SQC2005** – collect data that can be represented as a quadratic relation, from experiments using appropriate equipment and technology (e.g., concrete materials, scientific probes, graphing calculators), or from secondary sources (e.g., the Internet, Statistics Canada); graph the data and draw a curve of best fit, if appropriate, with or without the use of technology (Sample problem: Make a 1 m ramp that makes a 15° angle with the floor. Place a can 30 cm up the ramp. Record the time it takes for the can to roll to the bottom. Repeat by placing the can 40 cm, 50 cm, and 60 cm up the ramp, and so on. Graph the data and draw the curve of best fit.);
- [ ] **QR2.02** **SQC2005** – determine, through investigation using technology, that a quadratic relation of the form $y = ax^2 + bx + c$ (a not equal to 0) can be graphically represented as a parabola, and determine that the table of values yields a constant second difference (Sample problem: Graph the quadratic relation $y = x^2 – 4$, using technology. Observe the shape of the graph. Consider the corresponding table of values, and calculate the first and second differences. Repeat for a different quadratic relation. Describe your observations and make conclusions.);

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☐ **QR2.04** **SQC2005** – compare, through investigation using technology, the graphical representations of a quadratic relation in the form $y = x^2 + bx + c$ and the same relation in the factored form $y = (x – r)(x – s)$ (i.e., the graphs are the same), and describe the connections between each algebraic representation and the graph [e.g., the y-intercept is c in the form $y = x^2 + bx + c$; the x-intercepts are r and s in the form $y = (x – r)(x – s)$] (Sample problem: Use a graphing calculator to compare the graphs of $y = x^2 + 2x – 8$ and $y = (x + 4)(x – 2)$. In what way(s) are the equations related? What information about the graph can you identify by looking at each equation? Make some conclusions from your observations, and check your conclusions with a different quadratic equation.).

Solving Problems by Interpreting Graphs of Quadratic Relations

☐ **QR3.02** **SQC2005** – solve problems by interpreting the signifi- cance of the key features of graphs obtained by collecting experimental data involving quadratic relations (Sample problem: Roll a can up a ramp. Using a motion detector and a graphing calculator, record the motion of the can until it returns to its starting position, graph the distance from the starting position versus time, and draw the curve of best fit. Interpret the meanings of the vertex and the intercepts in terms of the experiment. Predict how the graph would change if you gave the can a harder push.Test your prediction.).

Gr.12 Advanced Functions---A. EXPONENTIAL AND LOGARITHMIC FUNCTIONS MHF 4U

1. Evaluating Logarithmic Expressions

☐ **EL1.01** **CR2007** 1.1 recognize the logarithm of a number to a given base as the exponent to which the base must be raised to get the number, recognize the operation of finding the logarithm to be the inverse operation (i.e., the undoing or reversing) of exponentiation, and evaluate simple logarithmic expressions Sample problem: Why is it not possible to determine $\log_{10}(– 3)$ or $\log_2 0$? Explain your reasoning.

2. Connecting Graphs and Equations of Logarithmic Functions

☐ **EL2.01** **CR2007** 2.1 determine, through investigation with technology (e.g., graphing calculator, spreadsheet) and without technology, key features (i.e., vertical and horizontal asymptotes, domain and range, intercepts, increasing/decreasing behaviour) of the graphs of logarithmic functions of the form $f(x) = \log_b x$, and make connections between the algebraic and graphical representations of these logarithmic functions Sample problem: Compare the key features of the graphs of $f(x) = \log_2 x$, $g(x) = \log_4 x$, and $h(x) = \log_8 x$ using graphing technology.

☐ **EL2.02** **CR2007** 2.2 recognize the relationship between an exponential function and the corresponding logarithmic function to be that of a function and its inverse, deduce that the graph of a logarithmic function is the reflection of the graph of the corresponding exponential function in the line y = x, and verify the deduction using technology Sample problem: Give examples to show that the inverse of a function is not necessarily a function. Use the key features of the graphs of logarithmic and exponential functions to give reasons why the inverse of an exponential function is a function.

☐ **EL2.03** **CR2007** 2.3 determine, through investigation using technology, the roles of the parameters d and c in functions of the form $y = \log_{10}(x – d) + c$ and the roles of the parameters a and k in functions of the form $y = a\log_{10}(kx)$, and describe these roles in terms of transformations on the graph of $f(x) = \log_{10}x$ (i.e., vertical and horizontal translations; reflections in the axes; vertical and horizontal stretches and compressions to and from the x-and y-axes) Sample problem: Investigate the graphs of $f(x) = \log_{10}(x) + c$, $f(x) = \log_{10}(x – d)$, $f(x) = a\log_{10} x$, and $f(x) = \log_{10}(kx)$ for various values of c, d, a, and k, using technology, describe the effects of changing these parameters in terms of transformations, and make connections to the transformations of other functions such as polynomial functions, exponential functions, and trigonometric functions.

☐ **EL2.04** **CR2007** 2.4 pose problems based on real-world applications of exponential and logarithmic functions (e.g., exponential growth and decay, the Richter scale, the pH scale, the decibel scale), and solve these and other such problems by using a given graph or a graph generated with technology from a table of values or from its equation Sample problem: The pH or acidity of a solution is given by the equation pH = –logC, where C is the concentration of $[H^+]$ ions in multiples of M = 1 mol/L. Use graphing software to graph this function. What is the change in pH if the solution is diluted from a concentration of 0.1M to a concentration of 0.01M? From 0.001M to 0.0001M? Describe the change in pH when the concentration of any acidic solution is reduced to 1/10 of its original concentration. Rearrange the given equation to determine concentration as a function of pH.

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3. Solving Exponential and Logarithmic Equations

- ☐ **EL3.01** **CR2007** 3.1 recognize equivalent algebraic expressions involving logarithms and exponents, and simplify expressions of these types Sample problem: Sketch the graphs of $f(x) = \log_{10}(100x)$ and $g(x) = 2 + \log_{10} x$, compare the graphs, and explain your findings algebraically.
- ☐ **EL3.02** **CR2007** 3.2 solve exponential equations in one variable by determining a common base (e.g., solve $4^x = 8^{x+3}$ by expressing each side as a power of 2) and by using logarithms (e.g., solve $4^x = 8^{x+3}$ by taking the logarithm base 2 of both sides), recognizing that logarithms base 10 are commonly used (e.g., solving $3^x = 7$ by taking the logarithm base 10 of both sides) Sample problem: Solve $300(1.05)^n = 600$ and $2^{x+2} – 2^x = 12$ either by finding a common base or by taking logarithms, and explain your choice of method in each case.
- ☐ **EL3.04** **CR2007** 3.4 solve problems involving exponential and logarithmic equations algebraically, including problems arising from real-world applications Sample problem: The pH or acidity of a solution is given by the equation pH = –logC, where C is the concentration of $[H^+]$ ions in multiples of M = 1 mol/L. You are given a solution of hydrochloric acid with a pH of 1.7 and asked to increase the pH of the solution by 1.4. Determine how much you must dilute the solution. Does your answer differ if you start with a pH of 2.2?

Gr.12 Advanced Functions---B. TRIGONOMETRIC FUNCTIONS MHF 4U

2. Connecting Graphs and Equations of Trigonometric Functions

- ☐ **TF2.05** **CR2007** 2.5 sketch graphs of $y = a \sin(k(x – d)) + c$ and $y = a \cos(k(x – d)) + c$ by applying transformations to the graphs of $f(x) = \sin x$ and $f(x) = \cos x$ with angles expressed in radians, and state the period, amplitude, and phase shift of the transformed functions Sample problem: Transform the graph of $f(x) = \cos x$ to sketch $g(x) = 3\cos(2x) – 1$, and state the period, amplitude, and phase shift of each function.
- ☐ **TF2.06** **CR2007** 2.6 represent a sinusoidal function with an equation, given its graph or its properties, with angles expressed in radians Sample problem: A sinusoidal function has an amplitude of 2 units, a period of p, and a maximum at (0, 3). Represent the function with an equation in two different ways.
- ☐ **TF2.07** **CR2007** 2.7 pose problems based on applications involving a trigonometric function with domain expressed in radians (e.g., seasonal changes in temperature, heights of tides, hours of daylight, displacements for oscillating springs), and solve these and other such problems by using a given graph or a graph generated with or without technology from a table of values or from its equation Sample problem: The population size, P, of owls (predators) in a certain region can be modelled by the function $P(t) = 1000 + 100 \sin (\pi t/12)$, where t represents 12 the time in months. The population size, p, of mice (prey) in the same region is given by pt $p(t) = 20\,000 + 4000 \cos (\pi t/12)$. Sketch the graphs of these functions, and pose and solve problems involving the relationships between the two populations over time.

3. Solving Trigonometric Equations

- ☐ **TF3.03** **CR2007** 3.3 recognize that trigonometric identities are equations that are true for every value in the domain (i.e., a counter-example can be used to show that an equation is not an identity), prove trigonometric identities through the application of reasoning skills, using a variety of relationships (e.g., $\tan x = \sin x/\cos x$; $\sin^2 x + \cos^2 x = 1$; the reciprocal identities; the compound angle formulas), and verify identities using technology Sample problem: Use the compound angle formulas to prove the double angle formulas.
- ☐ **TF3.04** **CR2007** 3.4 solve linear and quadratic trigonometric equations, with and without graphing technology, for the domain of real values from 0 to 2π, and solve related problems Sample problem: Solve the following trigonometric equations for $0 \le x \le 2\pi$, and verify by graphing with technology: $2\sin x + 1 = 0$; $2\sin^2 x + \sin x – 1 = 0$; $\sin x = \cos 2x$; $\cos 2x = 1/2$.

Gr.12 Advanced Functions---C. POLYNOMIAL AND RATIONAL FUNCTIONS MHF 4U

1. Connecting Graphs and Equations of Polynomial Functions

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☐ **PO1.02 CR2007** — 1.2 compare, through investigation using graphing technology, the numeric, graphical, and algebraic representations of polynomial (i.e., linear, quadratic, cubic, quartic) functions (e.g., compare finite differences in tables of values; investigate the effect of the degree of a polynomial function on the shape of its graph and the maximum number of x-intercepts; investigate the effect of varying the sign of the leading coefficient on the end behaviour of the function for very large positive or negative x-values) Sample problem: Investigate the maximum number of x-intercepts for linear, quadratic, cubic, and quartic functions using graphing technology.

☐ **PO1.03 CR2007** — 1.3 describe key features of the graphs of polynomial functions (e.g., the domain and range, the shape of the graphs, the end behaviour of the functions for very large positive or negative x-values) Sample problem: Describe and compare the key features of the graphs of the functions $f(x) = x$, $f(x) = x^2$, $f(x) = x^3$, $f(x) = x^3 + x^2$, and $f(x) = x^3 + x$.

☐ **PO1.05 CR2007** — 1.5 make connections, through investigation using graphing technology (e.g., dynamic geometry software), between a polynomial function given in factored form [e.g., $f(x) = 2(x – 3)(x + 2)(x – 1)$] and the x-intercepts of its graph, and sketch the graph of a polynomial function given in factored form using its key features (e.g., by determining intercepts and end behaviour; by locating positive and negative regions using test values between and on either side of the x-intercepts) Sample problem: Investigate, using graphing technology, the x-intercepts and the shapes of the graphs of polynomial functions with one or more repeated factors, for example, $f(x) = (x – 2)(x – 3)$, $f(x) = (x – 2)(x – 2)(x – 3)$, $f(x) = (x – 2)(x – 2)(x – 2)(x – 3)$, and $f(x) = (x + 2)(x + 2)(x – 2)(x – 2)(x – 3)$, by considering whether the factor is repeated an even or an odd number of times. Use your conclusions to sketch $f(x) = (x + 1)(x + 1)(x – 3)(x – 3)$, and verify using technology.

☐ **PO1.06 CR2007** — 1.6 determine, through investigation using technology, the roles of the parameters a, k, d, and c in functions of the form $y = af (k(x – d)) + c$, and describe these roles in terms of transformations on the graphs of $f(x) = x^3$and $f(x) = x^4$ (i.e., vertical and horizontal translations; reflections in the axes; vertical and horizontal stretches and compressions to and from the x-and y-axes) Sample problem: Investigate, using technology, the graph of $f(x) = 2(x – d)^3+ c$ for various values of d and c, and describe the effects of changing d and c in terms of transformations.

☐ **PO1.07 CR2007** — 1.7 determine an equation of a polynomial function that satisfies a given set of conditions (e.g., degree of the polynomial, intercepts, points on the function), using methods appropriate to the situation (e.g., using the x-intercepts of the function; using a trial-and-error process with a graphing calculator or graphing software; using finite differences), and recognize that there may be more than one polynomial function that can satisfy a given set of conditions (e.g., an infinite number of polynomial functions satisfy the condition that they have three given x-intercepts) Sample problem: Determine an equation for a fifth-degree polynomial function that intersects the x-axis at only 5, 1, and –5, and sketch the graph of the function.

☐ **PO1.08 CR2007** — 1.8 determine the equation of the family of polynomial functions with a given set of zeros and of the member of the family that passes through another given point [e.g., a family of polynomial functions of degree 3 with zeros 5, –3, and –2 is defined by the equation $f(x) = k(x – 5)(x + 3)(x + 2)$, where k is a real number, $k \neq 0$; the member of the family that passes through (–1, 24) is $f(x) =–2(x – 5)(x + 3)(x + 2)$] Sample problem: Investigate, using graphing technology, and determine a polynomial function that can be used to model the function $f(x) = \sin x$ over the interval $0 \leq x \leq 2\pi$.

☐ **PO1.09 CR2007** — 1.9 determine, through investigation, and compare the properties of even and odd polynomial functions [e.g., symmetry about the y-axis or the origin; the power of each term; the number of x-intercepts; $f(x) = f(–x)$or $f(–x) = –f(x)$], and determine whether a given polynomial function is even, odd, or neither Sample problem: Investigate numerically, graphically, and algebraically, with and without technology, the conditions under which an even function has an even number of x-intercepts.

2. Connecting Graphs and Equations of Rational Functions

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- ☐ **PO2.01** **CR2007** 2.1 determine, through investigation with and without technology, key features (i.e., vertical and horizontal asymptotes, domain and range, intercepts, positive/negative intervals, increasing/decreasing intervals) of the graphs of rational functions that are the reciprocals of linear and quadratic functions, and make connections between the algebraic and graphical representations of these rational functions [e.g., make connections between $f(x) = 1/[x^2 – 4]$ and its graph by using graphing technology and by reasoning that there are vertical asymptotes at $x = 2$ and $x =–2$ and a horizontal asymptote at $y = 0$ and that the function maintains the same sign as $f(x) = x^2– 4$] Sample problem: Investigate, with technology, the key features of the graphs of families of rational functions of the form $f(x) = 1/(x + n)$, and $f(x) = 1/[x^2 + n]$ where n is an integer, and make connections between the equations and key features of the graphs.

- ☐ **PO2.02** **CR2007** 2.2 determine, through investigation with and without technology, key features (i.e., vertical and horizontal asymptotes, domain and range, intercepts, positive/negative intervals, increasing/decreasing intervals) of the graphs of rational functions that have linear expressions in the numerator and denominator [e.g., $f(x) = 2x/[x– 3]$, $h(x) = x – 2/(3x + 4)$], and make connections between the algebraic and graphical representations of these rational functions Sample problem: Investigate, using graphing technology, key features of the graphs of the family of rational functions of the form $f(x) = 8x/(nx + 1)$ for n = 1, 2, 4, and 8, and make connections between the equations and the asymptotes.

3. Solving Polynomial and Rational Equations

- ☐ **PO3.01** **CR2007** 3.1 make connections, through investigation using technology (e.g., computer algebra systems), between the polynomial function f(x), the divisor x – a, the remainder from the division $f(x)/[x – a]$, and f(a) to verify the remainder theorem and the factor theorem Sample problem: Divide $f(x) = x^4 + 4x^3 – x^2 – 16x – 14$ by x – a for various integral values of a using a computer algebra system. Compare the remainder from each division with f(a).

- ☐ **PO3.02** **CR2007** 3.2 factor polynomial expressions in one variable, of degree no higher than four, by selecting and applying strategies (i.e., common factoring, difference of squares, trinomial factoring, factoring by grouping, remainder theorem, factor theorem) Sample problem: Factor: $x^3 + 2x^2 – x – 2$; $x^4 – 6x^3 + 4x^2 + 6x – 5$.

- ☐ **PO3.03** **CR2007** 3.3 determine, through investigation using technology (e.g., graphing calculator, computer algebra systems), the connection between the real roots of a polynomial equation and the x-intercepts of the graph of the corresponding polynomial function, and describe this connection [e.g., the real roots of the equation $x^4– 13x^2 + 36 = 0$ are the x-intercepts of the graph of $f(x) = x^4 – 13x^2 + 36$] Sample problem: Describe the relationship between the x-intercepts of the graphs of linear and quadratic functions and the real roots of the corresponding equations. Investigate, using technology, whether this relationship exists for polynomial functions of higher degree.

- ☐ **PO3.07** **CR2007** 3.7 solve problems involving applications of polynomial and simple rational functions and equations [e.g., problems involving the factor theorem or remainder theorem, such as determining the values of k for which the function $f(x) = x^3 + 6x^2 + kx – 4$ gives the same remainder when divided by x – 1 and x + 2] Sample problem: Use long division to express the given function $f(x) = [x^2 + 3x – 5]/[x – 1]$ as the sum of a polynomial function and a rational function of the form $A/(x – 1)$ (where A is a constant), make a conjecture about the relationship between the given function and the polynomial function for very large positive and negative x-values, and verify your conjecture using graphing technology.

Gr.12 Advanced Functions---D. CHARACTERISTICS OF FUNCTIONS MHF 4U

1. Understanding Rates of Change

- ☐ **CF1.02** **CR2007** 1.2 recognize that the rate of change for a function is a comparison of changes in the dependent variable to changes in the independent variable, and distinguish situations in which the rate of change is zero, constant, or changing by examining applications, including those arising from real-world situations (e.g., rate of change of the area of a circle as the radius increases, inflation rates, the rising trend in graduation rates among Aboriginal youth, speed of a cruising aircraft, speed of a cyclist climbing a hill, infection rates) Sample problem: The population of bacteria in a sample is 250 000 at 1:00 p.m., 500 000 at 3:00 p.m., and 1 000 000 at 5:00 p.m. Compare methods used to calculate the change in the population and the rate of change in the population between 1:00 p.m. to 5:00 p.m. Is the rate of change constant? Explain your reasoning.

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- ☐ **CF1.03** **CR2007** 1.3 sketch a graph that represents a relationship involving rate of change, as described in words, and verify with technology (e.g., motion sensor) when possible Sample problem: John rides his bicycle at a constant cruising speed along a flat road. He then decelerates (i.e., decreases speed) as he climbs a hill. At the top, he accelerates (i.e., increases speed) on a flat road back to his constant cruising speed, and he then accelerates down a hill. Finally, he comes to another hill and glides to a stop as he starts to climb. Sketch a graph of John's speed versus time and a graph of his distance travelled versus time.
- ☐ **CF1.04** **CR2007** 1.4 calculate and interpret average rates of change of functions (e.g., linear, quadratic, exponential, sinusoidal) arising from real-world applications (e.g., in the natural, physical, and social sciences), given various representations of the functions (e.g., tables of values, graphs, equations) Sample problem: Fluorine-20 is a radioactive substance that decays over time. At time 0, the mass of a sample of the substance is 20 g. The mass decreases to 10 g after 11 s, to 5 g after 22 s, and to 2.5 g after 33 s. Compare the average rate of change over the 33-s interval with the average rate of change over consecutive 11-s intervals.
- ☐ **CF1.05** **CR2007** 1.5 recognize examples of instantaneous rates of change arising from real-world situations, and make connections between instantaneous rates of change and average rates of change (e.g., an average rate of change can be used to approximate an instantaneous rate of change) Sample problem: In general, does the speedometer of a car measure instantaneous rate of change (i.e., instantaneous speed) or average rate of change (i.e., average speed)? Describe situations in which the instantaneous speed and the average speed would be the same.
- ☐ **CF1.06** **CR2007** 1.6 determine, through investigation using various representations of relationships (e.g., tables of values, graphs, equations), approximate instantaneous rates of change arising from real-world applications (e.g., in the natural, physical, and social sciences) by using average rates of change and reducing the interval over which the average rate of change is determined Sample problem: The distance, d metres, travelled by a falling object in t seconds is represented by $d = 5t^2$. When t = 3, the instantaneous speed of the object is 30 m/s. Compare the average speeds over different time intervals starting at t = 3 with the instantaneous speed when t = 3. Use your observations to select an interval that can be used to provide a good approximation of the instantaneous speed at t = 3.
- ☐ **CF1.07** **CR2007** 1.7 make connections, through investigation, between the slope of a secant on the graph of a function (e.g., quadratic, exponential, sinusoidal) and the average rate of change of the function over an interval, and between the slope of the tangent to a point on the graph of a function and the instantaneous rate of change of the function at that point Sample problem: Use tangents to investigate the behaviour of a function when the instantaneous rate of change is zero, positive, or negative.
- ☐ **CF1.09** **CR2007** 1.9 solve problems involving average and instantaneous rates of change, including problems arising from real-world applications, by using numerical and graphical methods (e.g., by using graphing technology to graph a tangent and measure its slope) Sample problem: The height, h metres, of a ball above the ground can be modelled by the function $h(t) =– 5t^2 + 20t$, where t is the time in seconds. Use average speeds to determine the approximate instantaneous speed at t = 3.

2. Combining Functions

- ☐ **CF2.01** **CR2007** 2.1 determine, through investigation using graphing technology, key features (e.g., domain, range, maximum/minimum points, number of zeros) of the graphs of functions created by adding, subtracting, multiplying, or dividing functions [e.g., $f(x) = 2^{-x} \sin 4x$, $g(x) = x^2 + 2^x$, h(x) = sin x/cos x], and describe factors that affect these properties Sample problem: Investigate the effect of the behaviours of f(x) = sin x, f(x) = sin2x, and f(x) = sin4x on the shape of f(x) = sin x + sin2x + sin4x.
- ☐ **CF2.02** **CR2007** 2.2 recognize real-world applications of combinations of functions (e.g., the motion of a damped pendulum can be represented by a function that is the product of a trigonometric function and an exponential function; the frequencies of tones associated with the numbers on a telephone involve the addition of two trigonometric functions), and solve related problems graphically Sample problem: The rate at which a contaminant leaves a storm sewer and enters a lake depends on two factors: the concentration of the contaminant in the water from the sewer and the rate at which the water leaves the sewer. Both of these factors vary with time. The concentration of the contaminant, in kilograms per cubic metre of water, is given by $c(t) = t^2$, where t is in seconds. The rate at which water leaves the sewer, in cubic metres per second, is given by $w(t) = 1/(t^4+ 10)$. Determine the time at which the contaminant leaves the sewer and enters the lake at the maximum rate.

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- ☐ **CF2.03 CR2007** 2.3 determine, through investigation, and explain some properties (i.e., odd, even, or neither; increasing/decreasing behaviours) of functions formed by adding, subtracting, multiplying, and dividing general functions [e.g., f(x) + g(x), f(x)g(x)] Sample problem: Investigate algebraically, and verify numerically and graphically, whether the product of two functions is even or odd if the two functions are both even or both odd, or if one function is even and the other is odd.

- ☐ **CF2.04 CR2007** 2.4 determine the composition of two functions [i.e., f(g(x))] numerically (i.e., by using a table of values) and graphically, with technology, for functions represented in a variety of ways (e.g., function machines, graphs, equations), and interpret the composition of two functions in real-world applications Sample problem: For a car travelling at a constant speed, the distance driven, d kilometres, is represented by d(t) = 80t, where t is the time in hours. The cost of gasoline, in dollars, for the drive is represented by C(d) = 0.09d. Determine numerically and interpret C(d(5)), and describe the relationship represented by C(d(t)).

- ☐ **CF2.05 CR2007** 2.5 determine algebraically the composition of two functions [i.e., f(g(x))], verify that f(g(x)) is not always equal to g(f(x)) [e.g., by determining f(g(x)) and g(f(x)), given f(x) = x + 1 and g(x) = 2x], and state the domain [i.e., by defining f(g(x)) for those x-values for which g(x) is defined and for which it is included in the domain of f(x)] and the range of the composition of two functions Sample problem: Determine f(g(x)) and g(f(x)) given f(x) = cos x and g(x) = 2x + 1, state the domain and range of f(g(x)) and g(f(x)), compare f(g(x)) with g(f(x)) algebraically, and verify numerically and graphically with technology.

- ☐ **CF2.06 CR2007** 2.6 solve problems involving the composition of two functions, including problems arising from real-world applications Sample problem: The speed of a car, v kilometres per hour, at a time of t hours is represented by $v(t) = 40 + 3t + t^2$. The rate of gasoline consumption of the car, c litres per kilometre, at a speed of v kilometres per hour is represented by $c(v) = (v/500 – 0.1)^2 + 0.15$. Determine algebraically c(v(t)), the rate of gasoline consumption as a function of time. Determine, using technology, the time when the car is running most economically during a four-hour trip.

- ☐ **CF2.08 CR2007** 2.8 make connections, through investigation using technology, between transformations (i.e., vertical and horizontal translations; reflections in the axes; vertical and horizontal stretches and compressions to and from the x-and y-axes) of simple functions f(x) [e.g., $f(x) = x^3 + 20$, f(x) = sin x, f(x) = log x] and the composition of these functions with a linear function of the form g(x) = A(x + B) Sample problem: Compare the graph of $f(x) = x^2$ with the graphs of f(g(x)) and g(f(x)), where g(x) = 2(x – d), for various values of d. Describe the effects of d in terms of transformations of f(x).

3. Using Function Models to Solve Problems

- ☐ **CF3.02 CR2007** 3.2 solve graphically and numerically equations and inequalities whose solutions are not accessible by standard algebraic techniques Sample problem: Solve: $2x^2 < 2^x$; cos x = x, with x in radians.

- ☐ **CF3.03 CR2007** 3.3 solve problems, using a variety of tools and strategies, including problems arising from real-world applications, by reasoning with functions and by applying concepts and procedures involving functions (e.g., by constructing a function model from data, using the model to determine mathematical results, and interpreting and communicating the results within the context of the problem) Sample problem: The pressure of a car tire with a slow leak is given in the following table of values: Time, t (min)*Pressure, P (kPa)*0*400*5*335*10*295*15*255*20*225*25*195*30*170 Use technology to investigate linear, quadratic, and exponential models for the relationship of the tire pressure and time, and describe how well each model fits the data. Use each model to predict the pressure after 60 min. Which model gives the most realistic answer?

Gr.9 Principles of Mathematics---Number Sense and Algebra MPM 1D

Operating with Exponents

- ☐ **NA1.01 SQC2005** – substitute into and evaluate algebraic expressions involving exponents (i.e., evaluate expressions involving natural-number exponents with rational-number bases [e.g., evaluate $(3/2)^3$ by hand and 9.83 by using a calculator]) (Sample problem: A movie theatre wants to compare the volumes of popcorn in two containers, a cube with edge length 8.1 cm and a cylinder with radius 4.5 cm and height 8.0 cm. Which container holds more popcorn?);

Manipulating Expressions and Solving Equations

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- ☐ **NA2.08** **SQC2005** – rearrange formulas involving variables in the first degree, with and without substitution (e.g., in analytic geometry, in measurement) (Sample problem: A circular garden has a circumference of 30 m. What is the length of a straight path that goes through the centre of this garden?);
- ☐ **NA2.09** **SQC2005** – solve problems that can be modelled with first-degree equations, and compare algebraic methods to other solution methods (Sample problem: Solve the following problem in more than one way: Jonah is involved in a walkathon. His goal is to walk 25 km. He begins at 9:00 a.m. and walks at a steady rate of 4 km/h. How many kilometres does he still have left to walk at 1:15 p.m. if he is to achieve his goal?).

Gr.9 Principles of Mathematics---Linear Relationships MPM 1D

Using Data Management to Investigate

- ☐ **LR1.01** **SQC2005** – interpret the meanings of points on scatter plots or graphs that represent linear relations, including scatter plots or graphs in more than one quadrant [e.g., on a scatter plot of height versus age, interpret the point (13, 150) as representing a student who is 13 years old and 150 cm tall; identify points on the graph that represent students who are taller and younger than this student] (Sample problem: Given a graph that represents the relationship of the Celsius scale and the Fahrenheit scale, determine the Celsius equivalent of –5°F.);
- ☐ **LR1.02** **SQC2005** – pose problems, identify variables, and formulate hypotheses associated with relationships between two variables (Sample problem: Does the rebound height of a ball depend on the height from which it was dropped?);
- ☐ **LR1.03** **SQC2005** – design and carry out an investigation or experiment involving relationships between two variables, including the collection and organization of data, using appropriate methods, equipment, and/or technology (e.g., surveying; using measuring tools, scientific probes, the Internet) and techniques (e.g., making tables, drawing graphs) (Sample problem: Design and perform an experiment to measure and record the temperature of ice water in a plastic cup and ice water in a thermal mug over a 30 min period, for the purpose of comparison. What factors might affect the outcome of this experiment? How could you design the experiment to account for them?);
- ☐ **LR1.04** **SQC2005** – describe trends and relationships observed in data, make inferences from data, compare the inferences with hypotheses about the data, and explain any differences between the inferences and the hypotheses (e.g., describe the trend observed in the data. Does a relationship seem to exist? Of what sort? Is the outcome consistent with your hypothesis? Identify and explain any outlying pieces of data. Suggest a formula that relates the variables. How might you vary this experiment to examine other relationships?) (Sample problem: Hypothesize the effect of the length of a pendulum on the time required for the pendulum to make five full swings. Use data to make an inference. Compare the inference with the hypothesis. Are there other relationships you might investigate involving pendulums?).

Understanding Characteristics of Linear Relations

- ☐ **LR2.01** **SQC2005** – construct tables of values, graphs, and equations, using a variety of tools (e.g., graphing calculators, spreadsheets, graphing software, paper and pencil), to represent linear relations derived from descriptions of realistic situations (Sample problem: Construct a table of values, a graph, and an equation to represent a monthly cellphone plan that costs $25, plus $0.10 per minute of airtime.);
- ☐ **LR2.02** **SQC2005** – construct tables of values, scatter plots, and lines or curves of best fit as appropriate, using a variety of tools (e.g., spreadsheets, graphing software, graphing calculators, paper and pencil), for linearly related and non-linearly related data collected from a variety of sources (e.g., experiments, electronic secondary sources, patterning with concrete materials) (Sample problem: Collect data, using concrete materials or dynamic geometry software, and construct a table of values, a scatter plot, and a line or curve of best fit to represent the following relationships: the volume and the height for a square-based prism with a fixed base; the volume and the side length of the base for a square-based prism with a fixed height.);
- ☐ **LR2.04** **SQC2005** – compare the properties of direct variation and partial variation in applications, and identify the initial value (e.g., for a relation described in words, or represented as a graph or an equation) (Sample problem: Yoga costs $20 for registration, plus $8 per class.Tai chi costs $12 per class. Which situation represents a direct variation, and which represents a partial variation? For each relation, what is the initial value? Explain your answers.);

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Connecting Various Representations of Linear Relations

- ☐ **LR3.01** **SQC2005** – determine values of a linear relation by using a table of values, by using the equation of the relation, and by interpolating or extrapolating from the graph of the relation (Sample problem: The equation H = 300 – 60t represents the height of a hot air balloon that is initially at 300 m and is descending at a constant rate of 60 m/min. Determine algebraically and graphically how long the balloon will take to reach a height of 160 m.);
- ☐ **LR3.02** **SQC2005** – describe a situation that would explain the events illustrated by a given graph of a relationship between two variables (Sample problem: The walk of an individual is illustrated in the given graph, produced by a motion detector and a graphing calculator. Describe the walk [e.g., the initial distance from the motion detector, the rate of walk].);

Gr.9 Principles of Mathematics---Analytic Geometry MPM 1D

Using the Properties of Linear Relations to Solve Problems

- ☐ **AG3.02** **SQC2005** – determine the equation of a line from information about the line (e.g., the slope and y-intercept; the slope and a point; two points) (Sample problem: Compare the equations of the lines parallel to and perpendicular to y = 2x – 4, and with the same x-intercept as 3x – 4y = 12.Verify using dynamic geometry software.);
- ☐ **AG3.05** **SQC2005** – determine graphically the point of intersection of two linear relations, and interpret the intersection point in the context of an application (Sample problem: A video rental company has two monthly plans. Plan A charges a flat fee of $30 for unlimited rentals; Plan B charges $9, plus $3 per video. Use a graphical model to determine the conditions under which you should choose Plan A or Plan B.).

Gr.9 Principles of Mathematics---Measurement and Geometry MPM 1D

Investigating the Optimal Value of Measurements

- ☐ **MG1.05** **SQC2005** – pose and solve problems involving maximization and minimization of measurements of geometric shapes and figures (e.g., determine the dimensions of the rectangular field with the maximum area that can be enclosed by a fixed amount of fencing, if the fencing is required on only three sides) (Sample problem: Determine the dimensions of a square-based, opentopped prism with a volume of 24 cm^3 and with the minimum surface area.).

Solving Problems Involving Perimeter, Area, Surface Area and Volume

- ☐ **MG2.03** **SQC2005** – solve problems involving the areas and perimeters of composite two-dimensional shapes (i.e., combinations of rectangles, triangles, parallelograms, trapezoids, and circles) (Sample problem: A new park is in the shape of an isosceles trapezoid with a square attached to the shortest side.The side lengths of the trapezoidal section are 200 m, 500 m, 500 m, and 800 m, and the side length of the square section is 200 m. If the park is to be fully fenced and sodded, how much fencing and sod are required?);
- ☐ **MG2.06** **SQC2005** – solve problems involving the surface areas and volumes of prisms, pyramids, cylinders, cones, and spheres, including composite figures (Sample problem: Break-bit Cereal is sold in a single-serving size, in a box in the shape of a rectangular prism of dimensions 5 cm by 4 cm by 10 cm. The manufacturer also sells the cereal in a larger size, in a box with dimensions double those of the smaller box. Compare the surface areas and the volumes of the two boxes, and explain the implications of your answers.).

Investigating and Applying Geometric Relationships

- ☐ **MG3.01** **SQC2005** – determine, through investigation using a variety of tools (e.g., dynamic geometry software, concrete materials), and describe the properties and relationships of the interior and exterior angles of triangles, quadrilaterals, and other polygons, and apply the results to problems involving the angles of polygons (Sample problem:With the assistance of dynamic geometry software, determine the relationship between the sum of the interior angles of a polygon and the number of sides. Use your conclusion to determine the sum of the interior angles of a 20-sided polygon.);

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within: **Mathematics**

- ☐ **MG3.03** **SQC2005** – pose questions about geometric relationships, investigate them, and present their findings, using a variety of mathematical forms (e.g., written explanations, diagrams, dynamic sketches, formulas, tables) (Sample problem: How many diagonals can be drawn from one vertex of a 20-sided polygon? How can I find out without counting them?);
- ☐ **MG3.04** **SQC2005** – illustrate a statement about a geometric property by demonstrating the statement with multiple examples, or deny the statement on the basis of a counter-example, with or without the use of dynamic geometry software (Sample problem: Confirm or deny the following statement: If a quadrilateral has perpendicular diagonals, then it is a square.).

Gr.9 Mathematics Transfer---Number Sense and Algebra MPM 1H

Manipulating Expressions and Solving Equations

- ☐ **NS2.05** **CR2006** – rearrange formulas involving variables in the first degree, with and without substitution (e.g., in analytic geometry, in measurement) (Sample problem: A circular garden has a circumference of 30 m. Write an expression for the length of a straight path that goes through the centre of this garden.);
- ☐ **NS2.06** **CR2006** – solve problems that can be modelled with first-degree equations, and compare algebraic methods to other solution methods (Sample problem: Solve the following problem in more than one way: Jonah is involved in a walkathon. His goal is to walk 25 km. He begins at 9:00 a.m. and walks at a steady rate of 4 km/h. How many kilometres does he still have left to walk at 1:15 p.m. if he is to achieve his goal?).

Gr.9 Mathematics Transfer---Analytic Geometry MPM 1H

Understanding Characteristics of Linear Relations

- ☐ **AG1.01** **CR2006** – design and carry out an investigation or experiment involving relationships between two variables, including the collection and organization of data, using appropriate methods, equipment, and/or technology (e.g., surveying; using measuring tools, scientific probes, the Internet) and techniques (e.g.,making tables, drawing graphs) (Sample problem: Design and perform an experiment to measure and record the temperature of ice water in a plastic cup and ice water in a thermal mug over a 30 min period, for the purpose of comparison. What factors might affect the outcome of this experiment? How could you design the experiment to account for them?);
- ☐ **AG1.02** **CR2006** – construct equations to represent linear relations derived from descriptions of realistic situations, and connect the equations to tables of values and graphs, using a variety of tools (e.g., graphing calculators, spreadsheets, graphing software, paper and pencil) (Sample problem: Construct a table of values, a graph, and an equation to represent a monthly cellphone plan that costs $25, plus $0.10 per minute of airtime.);

Using the Properties of Linear Relations to Solve Problems

- ☐ **AG4.02** **CR2006** – determine the equation of a line from information about the line (e.g., the slope and y-intercept; the slope and a point; two points) (Sample problem: Compare the equations of the lines parallel to and perpendicular to $y = 2x – 4$, and with the same x-intercept as $3x – 4y = 12$.Verify using dynamic geometry software.);

Gr.9 Mathematics Transfer---Measurement and Geometry MPM 1H

Solving Problems Involving Surface Area and Volume

- ☐ **MG1.03** **CR2006** – solve problems involving the surface areas of prisms, pyramids, cylinders, cones, and spheres, including composite figures (Sample problem: Break-bit Cereal is sold in a single-serving size, in a box in the shape of a rectangular prism of dimensions 5 cm by 4 cm by 10 cm. The manufacturer also sells the cereal in a larger size, in a box with dimensions double those of the smaller box. Compare the surface areas and the volumes of the two boxes, and explain the implications of your answers.);
- ☐ **MG1.06** **CR2006** – pose and solve problems involving maximization and minimization of measurements of geometric figures (i.e., squarebased prisms or cylinders) (Sample problem: Determine the dimensions of a square-based, open-topped prism with a volume of 24 cm^3 and with the minimum surface area.).

Investigating and Applying Geometric Relationships

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- ☐ **MG2.02** **CR2006** – pose questions about geometric relationships, investigate them, and present their findings, using a variety of mathematical forms (e.g., written explanations, diagrams, dynamic sketches, formulas, tables) (Sample problem: How many diagonals can be drawn from one vertex of a 20- sided polygon? How can I find out without counting them?);
- ☐ **MG2.03** **CR2006** – illustrate a statement about a geometric property by demonstrating the statement with multiple examples, or deny the statement on the basis of a counter-example, with or without the use of dynamic geometry software (Sample problem: Confirm or deny the following statement: If a quadrilateral has perpendicular diagonals, then it is a square.).

Gr.10 Principles of Mathematics---Quadratic Relations of the Form y = ax2 + bx + c MPM 2D

Investigating the Basic Properties of Quadratic Relations

- ☐ **QR1.01** **SQC2005** – collect data that can be represented as a quadratic relation, from experiments using appropriate equipment and technology (e.g., concrete materials, scientific probes, graphing calculators), or from secondary sources (e.g., the Internet, Statistics Canada); graph the data and draw a curve of best fit, if appropriate, with or without the use of technology (Sample problem: Make a 1 m ramp that makes a 15° angle with the floor. Place a can 30 cm up the ramp. Record the time it takes for the can to roll to the bottom. Repeat by placing the can 40 cm, 50 cm, and 60 cm up the ramp, and so on. Graph the data and draw the curve of best fit.);
- ☐ **QR1.02** **SQC2005** – determine, through investigation with and without the use of technology, that a quadratic relation of the form $y = ax^2 + bx + c$ (a not equal to 0) can be graphically represented as a parabola, and that the table of values yields a constant second difference (Sample problem: Graph the relation $y = x^2 – 4x$ by developing a table of values and plotting points. Observe the shape of the graph. Calculate first and second differences. Repeat for different quadratic relations. Describe your observations and make conclusions, using the appropriate terminology.);

Relating the Graph of $y = x^2$ and Its Transformations

- ☐ **QR2.03** **SQC2005** – sketch, by hand, the graph of $y = a(x – h)^2 + k$ by applying transformations to the graph of $y = x^2$ [Sample problem: Sketch the graph of $y = –1/2 (x – 3)^2 + 4$, and verify using technology.];

Solving Quadratic Equations

- ☐ **QR3.08** **SQC2005** – solve quadratic equations that have real roots, using a variety of methods (i.e., factoring, using the quadratic formula, graphing) (Sample problem: Solve $x^2 + 10x + 16 = 0$ by factoring, and verify algebraically. Solve $x^2 + x – 4 = 0$ using the quadratic formula, and verify graphically using technology. Solve $–4.9t^2 + 50t + 1.5 = 0$ by graphing $h = –4.9t^2 + 50t + 1.5$ using technology.).

Gr.10 Principles of Mathematics---Analytic Geometry MPM 2D

Using Linear Systems to Solve Problems

- ☐ **AG1.01** **SQC2005** – solve systems of two linear equations involving two variables, using the algebraic method of substitution or elimination (Sample problem: Solve $y = 1/2x – 5$, $3x + 2y = –2$ for x and y algebraically, and verify algebraically and graphically);
- ☐ **AG1.02** **SQC2005** – solve problems that arise from realistic situations described in words or represented by linear systems of two equations involving two variables, by choosing an appropriate algebraic or graphical method (Sample problem: The Robotics Club raised $5000 to build a robot for a future competition. The club invested part of the money in an account that paid 4% annual interest, and the rest in a government bond that paid 3.5% simple interest per year. After one year, the club earned a total of $190 in interest. How much was invested at each rate? Verify your result.).

Gr.10 Principles of Mathematics---Trigonometry MPM 2D

Investigating Similarity and Solving Problems Involving Similar Triangles

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within: **Mathematics**

- ☐ **TR1.03** **SQC2005** – solve problems involving similar triangles in realistic situations (e.g., shadows, reflections, scale models, surveying) (Sample problem: Use a metre stick to determine the height of a tree, by means of the similar triangles formed by the tree, the metre stick, and their shadows.).

Solving Problems Involving the Trigonometry of Acute Triangles

- ☐ **TR3.03** **SQC2005** – determine the measures of sides and angles in acute triangles, using the sine law and the cosine law (Sample problem: In triangle ABC, LA = 35°, LB = 65°, and AC = 18 cm. Determine BC. Check your result using dynamic geometry software.);